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MODERN SEAMANSHIP

BY

AUSTIN M. KNIGHT

LATE REAR ADMIRAL, UNITED STATES NAVY

TENTH EDITION

REWRITTEN AND REVISED

BY THE OFFICERS

OF THE DEPARTMENT OF SEAMANSHIP AND NAVIGATION

UNITED STATES NAVAL ACADEMY

ANNAPOLIS, MARYLAND

NEW YORK

D. VAN NOSTRAND COMPANY, INC.

250 FOURTH AVENUE

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TENTH EDITION

Reprinted with changes and revisions,
June 1941, January 1942, March 1942, July 1942

PRINTED IN U. S. A.

PREFACE TO THE TENTH EDITION (REVISED)

This tenth edition of Modern Seamanship has been revised by the Officers of the Department of Seamanship and Navigation, United States Naval Academy. In this revision the Rules of the Road have been brought up to date to include the latest changes in Pilot Rules and the Motorboat Act, the recent court decision in the "El Isleo" case, and a number of color plates of lights required of vessels by the Inland and International Rules. In addition the chapter on Weather has been re-written.

C. H. COBB
Captain, U. S. Navy.
Head of Department of Seamanship
and Navigation

U. S. Naval Academy,
Annapolis, Md.
June, 1941.

An attempt is made, in the following pages, to cover a wider field than that covered by most of the existing works on Seamanship.

The admirable treatises of Luce, Nares, and Alston, originating in the days when seamanship was almost wholly concerned with the fitting and handling of vessels under sail, have preserved through later editions the general characteristics which they naturally assumed in the beginning. These treatises will never be out of date until the time, still far in the future, when sails shall have been entirely driven out by steam. It will hardly be denied, however, that the Steamer has long since established its claim to consideration in Seamanship, and that there is room for a work in which this claim shall be more fully recognized than in the treatises above referred to. The excellent work of Captains Todd and Whall, "Practical Seamanship for the Merchant Service," deals more fully than either of its predecessors with the handling of steamers; but its point of view is, as its name implies, primarily and almost exclusively that of the Merchant Service.

Shortly after the present work was begun, a circular letter was addressed to officers of the merchant service and extensively circulated through the Branch Hydrographic Offices at New York, Philadelphia, Baltimore and Norfolk, requesting the views of the officers addressed.

The answers received to these questions were unexpectedly numerous and complete. More than forty prominent officers of the Merchant Service replied, many of them writing out their views and describing their experiences with a fullness of detail far beyond anything that could have been anticipated.

The thanks of the author are due particularly to the following for letters or for personal interviews covering the above points: Capt. W. H. Thompson, S. S. Belgenland; Capt. T. Evans, S. S. Runo; Capt. J. Dann, S. S. Southwark; 1st Officer T. Anfindsen, S. S. Southwark; Capt. J. C. Jameson, S. S. St. Paul; Capt. H. E. Nickels, S. S. Friesland; Capt. G. J. Loveridge, S. S. Buffalo; Capt. F. M. Howes, S. S. Kershaw; Capt. T. J. Thorkildsen, S. S. Trojan; Capt. Otto Neilsen, S. S. Pennland.

Capt. H. Doxrud, S. S. Noordland; Capt. C. O. Rockwell, Clyde S. S. Co.; Capt. S. W. Watkins, S. S. Montana; Capt. Anders Beer, S. S. Nordkyn; Capt. J. M. Johnston, S. S. Sardinian; Capt. A. R. Mills, S. S. Westernland; Capt. J. S. Garvin, S. S. Cherokee; Capt. Robt. B. Quick, S. S. El Cid; Capt. Wm. J. Roberts, S. S. New York; Capt. T. Richardson, S. S. Noranmore; Capt. E. O. Marshall, S. S. Maryland; 1st Officer H. S. Lane, S. S. Maryland; Capt. W. F. Bingham, S. S. Marengo; Capt. R. Gowing, S. S. Greatham; Capt. H. J. Byrne, U. S. A. T. McPherson; Capt. Paul Grosch, S. S. Stuttgart; Capt. Geo. Schrotter, S. S. Belgravia; Capt. F. C. Saunders, S. S. English King; Capt. Chas. Cabot, S. S. Venango; Capt. Chas. Pinkham, S. S. Queen Wilhelmina; Capt. A. Traue, S. S. München; Capt. W. Thomas, S. S. Quernmore; Capt. H. O. Nickerson, Fall River Line; Capt. Geo. Lane, Baltimore Steam Packet Co.

Important assistance was received from Naval Constructor W. J. Baxter, U. S. Navy, who prepared Chapters I and XVIII; and from Lieutenant E. E. Hayden, U. S. Navy, who contributed several Charts and much valuable information upon Meteorology, for Chapter XIX.

Chapter V was suggested by a paper, "Mechanical Appliances on board Ship," by Captain Thomas Mackenzie, issued by the London Shipmasters' Society as No. 29 of their valuable series of publications.

It would be impossible to mention all the naval officers who have assisted the author with criticism and suggestions; but acknowledgment is especially due to Lieut.-Commander A. W. Grant, Lieut. John Hood, Lieut. W. R. M. Field, Lieut. John Gow, Lieut.-Commander W. F. Worthington, Commander J. E. Pillsbury, Lieut. V. S. Nelson, Lieut. Ridgely Hunt, and Chief Boatswain W. L. Hill, all of the United States Navy.

Above all, acknowledgment is due to Chief Boatswain C. F. Pierce, U. S. Navy, who not only assisted in the preparation of many parts of the text, but prepared sketches for fully one-half the illustrations of the volume.

AUSTIN M. KNIGHT.

UNITED STATES NAVAL ACADEMY,
APRIL 1, 1901.

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CHAPTER I.

THE SHIP.

The size, form, speed, power, armor, underwater protection, armament and rig of a ship depend upon the nature of the services she is expected to perform. Whatever her design may be, she must have ample stability, strength, habitability, and a complete outfit of all appliances, fixed and portable, necessary to ensure her efficiency under all service conditions.

The broadest classification of ships is that which distinguishes them as *Ships of War* and *Merchant Ships*. Ships of War in turn may be distinguished as *Fighting Ships* and *Auxiliaries*.

In view of the complications arising during the World War due to the new use to which submarines were put, followed by the "arming" of merchant vessels, both publicly and privately owned, some authorities claim that a better classification would be "combatant ships" and "non-combatant ships." With the coming of the commercial and military rigid airships (dirigibles) as well as with the rapidly increasing development of heavier-than-air ships, both commercial and military, the proper classification will be more difficult to make.

Fighting Ships and Auxiliaries.

Our principal concern is with fighting ships; but it must not be forgotten that in these days of large naval and military operations, often at great distances from home ports, the life of the fighting fleet, in addition to strategically placed bases, depends very largely upon its auxiliaries—fuel ships, supply ships, repair ships, etc.—forming the complex organization known as the *Train*.

Fighting Ships are of many classes, used for widely varying purposes calling for widely varying designs—designs which, starting from certain definite limitations of size and cost, must be developed along such lines and with such a balance of the

factors of offensive and defensive power involved, as shall give maximum weight to the factors most important for the purpose in hand without unduly sacrificing the remaining factors.

Modern warships are usually classified as follows:

For Service With the Fleet.

Fighting Units.

- Battleships
- Air-craft carriers
- Battle cruisers
- Heavy cruisers
- Light cruisers
- Anti-aircraft ships
- Destroyer leaders
- Destroyers
- Submarines
- Submarine mine layers
- Rigid airships
- Mine layers
- Light mine layers

Auxiliary Units (the Train).

- Destroyer tenders [1]
- Submarine tenders [1]
- Mine sweeping vessels [1]
- Air-craft tenders [1]
- Fuel ships
- Supply ships
- Transports
- Repair ships
- Hospital ships
- Ammunition ships

For Independent Service (Special Duty Ships).

- Cruisers
- Submarines
- Air-craft, both lighter and heavier than air
- Yachts
- Miscellaneous auxiliaries
- Gunboats
- Mine layers
- Submarine chasers
- Patrol vessels

For Coast Defense.

- Second-line battleships
- Second-line destroyers
- Second-line submarines
- Mine layers
- Patrol ships
- Air-craft

[1] In the U. S. Navy, destroyer and submarine tenders, etc., may also serve with the *Fighting Ships* or Fleets, and in this case they are not placed in the *Train*, but under their own individual respective *unit* commanders for administration.

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U. S. S. WEST VIRGINIA—BATTLESHIP.

(Note the airplane stowage on catapults on Nos. 3 and 4 turrets.)

Battleships. (Plate **1**). A *battleship*, being designed to take a place in the line of battle, meeting the most powerful ships of the enemy and exchanging blow for blow, must have defensive qualities to resist the heaviest blows she is likely to receive. Hence her armor and underwater protection must be heavy. But more important than the power to resist is the power to strike. It is an axiom that "the best defense is a vigorous offense." Thus, for a battleship the *first* requisite is a heavy armament; the *second*, heavy armor. Speed is here not of maximum importance, although by no means negligible. In the design of a battleship, then, we sacrifice something in weight of armor for weight of armament, and something in weight of boilers and engines—that is to say, in speed—for armament and armor combined; while for these three primary factors taken together —armament, armor, and speed—we sacrifice much in the important factor of fuel—endurance and in other less significant factors which need not be enumerated here.

The battleship now incorporates certain structural arrangements along the water line and below, in the way of the magazines, boiler and machinery spaces, to give added underwater protection from mine, bomb and torpedo attack, including the attack by the same weapons from aircraft.

It may be remarked that the battleship is the only type of surface craft capable of affording the maximum protection from aircraft attack. The long contest between the gun and armor, with the advantage first on one side and then on the other, promises to be repeated in the contest between the attacks of the aircraft's weapons and the defense against them. It goes without saying that the battleship is also capable of carrying the most powerful anti-aircraft battery.

Up to the time of the Russo-Japanese War, 1904–5, and for some years thereafter, the common type of battleship carried a mixed armament of heavy, light, and intermediate guns. As a result of experience gained in that war, Great Britain in 1906 laid down, with much secrecy, a new type, the distinguishing feature of which was that it carried only guns of the heaviest caliber and all of these protected by the heaviest armor. The first of these "all big-gun" ships was named the "Dreadnought" and this name was immediately seized upon as the name of the type, so that "Dreadnought" came to signify, at first an all-big-

© Courtesy U. S. Navy Recruiting Bureau.

U. S. S. RANGER—AIRCRAFT CARRIER.

Plate No. 2

gun ship, and, later a powerful battleship of any type without reference to the character of the armament. Following this, we have had "Super-Dreadnoughts," the term being used in a popular way to designate a ship which is assumed to be more powerful than any of its predecessors. The pendulum whose swing from too great diversity of armament led for a time to the removal of all except the heaviest guns has swung back to some extent, and even the super-dreadnought of today carries a battery of light guns for defense against torpedo craft and submarines, while ships of every class carry "anti-aircraft guns" capable of firing almost directly upward.

Although the *Monitor* type of coast defense ship is obsolete, it is worthy of mention here, if only because of its relation to the Dreadnought of today. The Dreadnought is, in fact, the logical outgrowth of the American Monitor of 1862. In the original Monitor we have a typical "all-big-gun" ship, with all (both) of its guns of the heaviest caliber known at that day, and all (both) of these guns carried in a revolving turret behind heavy armor. The hull, too, was protected as completely as possible, and the ship was maneuvered from an armored conning tower. From the Monitor to the Super-Dreadnought the road is long, but direct; if the road has sometimes deviated from a straight line, it has been only to come back to the line marked out by Ericsson.

Aircraft Carriers (Plates **2** and **3**). Ships specially designed to carry aircraft are known as aircraft carriers. Their special characteristics include: (*a*) high speed; (*b*) seaworthiness; (*c*) an unobstructed deck for flying off, landing, and parking; (*d*) stowage of planes and minor repairs, and habitability for personnel; (*e*) non-interference of smoke and gases from main power plant with plane operations; and (*f*) rapid means for conveying planes from below to the flight deck.

The *U. S. S. Saratoga* (Plate **3**) has a complement of 1,815 men and 219 officers; while the type and squadrons and number of planes may be varied according to changes in doctrine, etc., it may be said that this type of carrier can accommodate two squadrons of heavy planes for combining the functions of scouting, heavy bombing, and torpedo carrying, and, in addition, two squadrons of fighting planes. This vessel and her sister ship, the

© *Courtesy of the Panama Canal.*

U. S. S. SARATOGA (AIRCRAFT CARRIER) AND FRENCH CRUISER JEANNE D'ARC in PEDRO MIGUEL LOCKS, PANAMA CANAL.

U. S. S. Lexington, were originally laid down as battle cruisers, but later converted to aircraft carriers. They have a displacement of 33,000 tons, and have a speed of about 34 knots.

The *U. S. S. Ranger* (Plate **2**), a later type of carrier, was laid down in 1931 and completed in 1934. Her complement is 1,788, of whom 162 are commissioned officers. Displacement is about 14,000 tons with a speed of about 29 knots. Guns, eight 5-inch A.A. Plane carrying capacity about 75 aircraft.

Three additional 20,000-ton carriers are in the process of building.

Battle Cruisers. (Plate **4**). In a battle cruiser, the requirement of high speed comes first, accompanied by that of large fuel supply, or what is the same thing, radius of operations.

Next in importance comes armament; while armor protection drops to third place with an importance much below that of the other factors. While the battleship holds its place in the battle line, the battle cruiser may range far afield searching for the enemy—thus playing the part of an advanced scout—or take advantage of its high speed and heavy armament to turn the enemy's flank or throw itself upon some part of the line where its weight, coming perhaps as a surprise, may produce decisive results. A force of battle cruisers may be described as the heavy cavalry of the sea. Such a force gives flexibility to the fleet of which it forms a part and lends itself to combinations which afford scope for a high order of tactical skill on the part of the commander-in-chief.

At the time of the Washington Disarmament Conference there was a tendency to combine the characteristics of the battleship and the battle cruiser in a single design. This tendency, carried to full realization, would have resulted in a ship having the armor and armament of the *California* with a speed 30 per cent higher. Such a combination is possible only by an enormous increase in displacement, and would result in a ship of approximately 60,000 tons, a little short of 1,000 feet in length (to admit a passage through the locks of the Panama Canal) and with a draft of nearly or quite 40 feet. The British battle cruiser *Hood* is the nearest approach to it thus far attempted.

None of the Powers has announced any intentions of substituting battle cruiser tonnage for battleship tonnage in replacement construction. In fact Great Britain has built two replace-

(© Courtesy Office of Naval Records and Library)

H. M. S. HOOD—BATTLE CRUISER.

ment battleships, the *Nelson* and the *Rodney*. It seems likely, therefore, that the battle cruiser will disappear until new conditions warrant its reappearance.

Heavy Cruisers. (Plate **5**). A cruiser needs, first of all, high speed, which, however, must be accompanied by large fuel capacity and a high degree of seaworthiness, both of which characteristics are necessary to make high speed available for distant scouting (one of its main functions), under all conditions of weather.

A typical example of a heavy cruiser is the *U. S. S. Tuscaloosa* (Plate **5**), which has the following characteristics: Laid down, 1931; completed, 1934; displacement, 10,000 tons; speed, about 32 knots; main battery, nine 8-inch guns; anti-aircraft battery, eight 5-inch guns; aircraft, 4; catapults, 2.

Light Cruisers. The *U. S. S. Brooklyn* is an example of the latest type of light cruiser now being built by the United States. Displacement of this type is 10,000 tons.

The *U. S. S. Concord* (Plate **6**) is an example of an earlier type of light cruiser, having the following characteristics: Laid down, 1920; completed, 1923; displacement, 7,500 tons; speed, about 33.5 knots; battery, twelve 6-inch and four 3-inch anti-aircraft guns; torpedoes, 6. Aircraft are also carried in this type of ship.

Light cruisers usually operate with the fleet, especially in the preliminary stages of contact with the enemy. It is their function to keep touch with the enemy, reporting his movements, his forces, etc., to the Commander-in-Chief and drive back the enemy cruisers and destroyers if these attempt to attack. Their armament, especially designed for stopping other cruisers and destroyers, consists of a large number of light rapid-firing guns. This, coupled with their high speed and great flexibility of maneuvering, gives them wide range of usefulness within limits which do not take them far from base or support.

Destroyers. (Plate **7**). The destroyer has passed through many phases of evolution since it was first conceived as a craft designed to "destroy" the torpedo boats by which torpedo warfare was chiefly conducted fifty years ago. The earlier torpedo boat rapidly gave place to the larger but very similar craft that had been called into existence to oppose it, and the name "torpedo-boat destroyer" soon gave place to the abbreviated form

U. S. S. TUSCALOOSA—HEAVY CRUISER

© Courtesy of Bureau Construction and Repair.

now in every-day use. Primarily, then, the destroyer is a torpedo boat—large, heavily armed, and the fastest type of warship known. The light guns with which it was originally equipped for use against the thin plating of other torpedo craft have grown to a size and power that place the destroyer offensively, and without reference to its torpedoes, in a class with large gunboats and light cruisers, while its great speed and the large number of torpedoes that it carries place it distinctly in a class by itself.

The World War of 1914 to 1918 resulted in great developments in the characteristics of the destroyer and a wide extension of its field of usefulness. It proved the most efficient opponent of the submarine and the most successful protector of commerce from submarine and other forms of attack. Among the many novel features that were developed as weapons during the war, the most interesting were the *depth charge* and the *direction-listening device*, both of which found their most important and successful application on destroyers.

Two types of destroyers are shown in Plate **7A** and **7B**. The old flush deck type of 1,215 tons displacement which the United States built in large numbers just after the World War carries four 4-inch guns and one 3-inch anti-aircraft gun, and twelve torpedo tubes arranged in triple tube mounts.

The *U. S. S. Dewey* (No. 349), is an example of the latest type destroyer and has the following characteristics: Laid down, 1932; completed, 1934; displacement, 1,500 tons; guns, five 5-inch; torpedo tubes, eight 21-inch in two quadruple mounts; designed speed, 36.5 knots.

Submarines. (Plate **8**). The submarine, in principle, goes back to the inventions and experiments of Bushnell (1775) and Fulton (1801), although in its modern and successful application, it dates from the pioneer work of Holland (1875) and Lake (1895).

The modern submarine, unlike its predecessor of a few years back, which was greatly dependent on a "tender" or shore base for frequent services, is almost as self-sustaining and independent as any other type of ship, and with its large cruising radius is well fitted to act in the rôle of a scout, as it undoubtedly will be called upon to do in any future wars.

Contrary to the general impression, the normal life of a sub-

U. S. S. CONCORD—LIGHT CRUISER.

(There are two catapults on deck abaft after funnel, one on each side, for airplanes.)

marine is on the surface, where she is propelled by her Diesel oil engines. By arrangement of horizontal fin-like rudders on each end of the ship and ballast tanks which are flooded to destroy buoyancy, the submarine can pass from the surface to a depth which is limited only by the power of the hull to withstand the pressure of the water. While submerged, her motive power comes from storage batteries furnishing electricity to motors which drive propeller shafts. Thus the speed and distance which can be run submerged is quite limited and dependent on the storage batteries, which are charged by the ship's engines on the surface.

The submarine is not the always-invisible enemy that it is generally considered to be. Unless the periscope is above water, the submarine is blind, and when exposed, small as it is, it is open to detection by a keen lookout. Also, there is the danger of detection by sound; listening devices for picking up the sound of propellers are installed on all vessels designed to cope with submarines. Further, there is the danger of detection by aircraft which can see to a considerable distance below water and locate a submarine even when the periscope is not exposed. Once detected, the submarine must either come to the surface and face gunfire or remain submerged and accept the danger of depth bomb attacks.

While the submarine's main weapon is the torpedo coupled with its inherent ability to attack unseen, modern submarines carrying guns of 5 and 6 inches become formidable antagonists to a destroyer in a surface action. Mine-laying submarines possess the advantage of being able to lay mines without the protection of the large escort required by surface mine layers.

Plate No. **8** shows three types of submarines with widely varying characteristics. The *U. S. S. Narwhal* (N-1 ex V-5), completed in 1930, has a displacement of 2,730 tons, carries two 6-inch guns and six 21-inch torpedo tubes. Complement is 88 men.

U. S. S. Tarpon (P-4), completed in 1936, has a displacement of 1,315 tons, carries one 3-inch anti-aircraft gun and six 21-inch torpedo tubes. Complement is 50 men.

U. S. S. S-45, completed 1924, has a displacement of 850 tons, carries one 4-inch gun and four 21-inch torpedo tubes. Complement is 38 men.

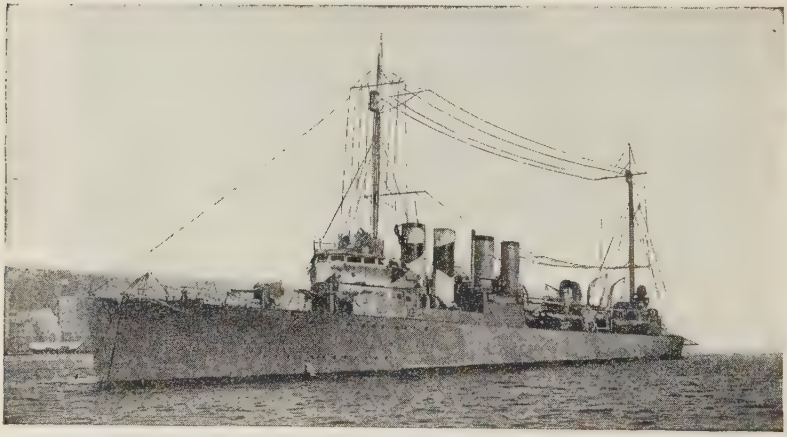
© *Courtesy U. S. Navy Recruiting Bureau.*

U. S. S. DEWEY—1500-TON DESTROYER.

Naval Auxiliaries. (Plate **9**). Space does not allow a description of the many types of vessels which come under this heading, but their importance and highly specialized characteristics in serving the fleet should be recognized. It is no longer felt that the upkeep of the fleet can be left to the chance of finding merchant ships which, when required, can be utilized to carry fuel, ammunition, provisions, etc., for a large fleet of various types of men-of-war acting in distant waters, whether in peace or war.

In this connection it is worthy of mention that much of the upkeep and repair work of every type of combatant ship from submarine to battleship is done by fleet repair ships and tenders.

Plate No. 7B



A DESTROYER.

Special Duty Ships. (Plate **10**). The desirability—indeed the necessity—of keeping the fighting fleet together, to be constantly in training for operations as a unit, makes it necessary for governments having interests in distant quarters of the world to maintain a certain number of ships for independent service in foreign waters. As a rule, the ships employed in this service are cruisers or gunboats of moderate size, preferably armed with many guns of medium and small caliber, and carrying crews large enough to permit the landing, in case of necessity, of an effective force of men.

Plate No. **10** shows two types of gunboats with following char-

U. S. S. NARWHAL—"V" TYPE SUBMARINE.

U. S. S.—S-45.

© Courtesy Bureau Construction and Repair.

U. S. S. TARPON—"P" TYPE SUBMARINE.

© *Courtesy Bureau of Construction and Repair.*

U. S. S. HOLLAND—SUBMARINE TENDER.

U. S. S. ERIE—GUNBOAT.

U. S. S. PANAY—RIVER GUNBOAT.

acteristics: *U. S. S. Erie,* completed 1936; displacement, 2,000 tons; armament, four 6-inch and four anti-aircraft machine guns; designed speed, 20 knots. One seaplane is carried on deck.

U. S. S. Panay, completed 1927; displacement, 450 tons; armament, two 3-inch guns. Designed speed, 15 knots. This type gunboat is of shallow draft (6 feet average), and was built solely for river duty. It has triple expansion engines, and is fitted with three rudders for navigating rivers with swift currents. It finds its chief use in the rivers of China where all the principal naval powers maintain such ships.

Coast Defense Ships. For the "Second Line of Defense" reliance is placed upon battleships and destroyers a little out of date for the "First Line" (the fleet), associated with such other craft, usually rather heterogeneous in character, as may be available. *Minelayers* are likely to develop into a definite and useful type as a result of the experience gained during the World War; and *aircraft,* operating far to seaward from a land base, or from aircraft carriers of good size, high speed and ample deck space, equipped with elaborate facilities for the stowage, handling, launching and landing of aircraft, will be a feature of all future defensive operations. Small, light, fast craft of the general type known during the World War as "submarine chasers" will patrol the coast, and, in connection with destroyers, convoy merchant vessels through regions where submarine activities are to be feared.

Naval Aviation has made such vast strides, in company with commercial aviation, in the past few years, that it is difficult to keep pace with it in any text or reference book, and only the salient points can be referred to in this book on seamanship. One point must be kept in mind as regards navy airplanes for use aboard ship, namely, that they must be relatively small, compact and strong, capable of being assembled and disassembled simply and quickly. They must stow in a small space, must be easily handled for launching, and should be fitted, if practicable, to withstand the severe strains incident to landing on rough water and riding out a gale if necessary. These requirements are radically different from those involved in the design of land planes and far more difficult of realization.

The rigid dirigible, lighter-than-air craft, is still largely experimental for commercial as well as for military and naval uses.

© "Official photograph, U. S. Navy."

PLANE BEING CATAPULTED FROM U. S. S. WEST VIRGINIA.

The most important naval field appears to be in long distance over seas scouting and reconnaissance.

Since 1925 the junior officer of the United States Navy has received instruction in naval aviation, both theoretical and practical, covering: Aviation History, Aircraft Instruments, Aerial Navigation, Aircraft Communications, Elementary Aerodynamics, Aircraft Power Plants, Aerial Gunnery, Elementary Flight Tactics, Aerology, Structure and Rigging, together with practical work in gunnery, engines, navigation, radio, and handling planes on the water, also a limited amount of flight training before assignment to the aviator's course at Pensacola.

The missions of naval heavier-than-air craft are: Airplanes would be used for bombing combatant ships, strafing, attacks against light forces, torpedoing capital ships, laying smoke screens, tactical scouting, observation of gun fire, destruction of enemy planes, early information of the enemy even at great distances from the fleet, locating and attacking enemy combatant ships operating on our lines of communication, and in attacks on shore objectives.

"The airplane in naval operations is at once a vehicle, a high observation post, a gun, a torpedo tube, a depth charge projector, a mine layer, and a smoke screen layer. The field of naval aircraft operations at sea is as wide as the Navy itself, no wider. Aircraft have an important application in the operation of all ships, and all forces afloat—in all classes of service. We may speak of aircraft carriers in much the same comprehensive sense that we speak of gun carriers or torpedo carriers or mine layers." [2]

Our own Navy's experience with aviation has been similar to that with destroyers and submarines. As soon as our destroyers and submarines really went to sea and operated with the fleet the greatest rate of progress in design, material and operating efficiency took place; and today, with naval aviation at sea with the fleet, and not confined to coastal bases, except for purely coast defense operations, aviation has taken its place alongside of the other units that go to make up the Fleet.

Today the United States Fleet is just as air-minded as it is strong for the destroyer forces, the light forces, the submarines,

[2] "Naval Aviation", revised edition, by Lieutenant Commander V. F. Grant, U. S. Navy, published by the U. S. Naval Institute, Annapolis, Md.

the mine forces, etc. No one can foretell at this time the future limitations of naval aviation, but one thing seems fairly certain, and that is, that aircraft have certain limitations as regards weather, navigation, power plants, habitability, bases, etc., that are common to surface craft. The greatest single factor in aircraft is *speed.*

Aside from the *technique* of getting any aircraft away from the surface of the earth and landing, *and of certain aerial maneuvers,* the *handling* of the airship, including navigation, is so analogous to that of the surface ships, that regarded broadly, it may be considered a matter of *Seamanship,* or the art of handling ships. In this sense airmanship may be said to be included in the more general term seamanship.

Merchant Steamers (Plate **12**) are of many types, varying in their characteristics even more widely than men-of-war. They may be broadly divided into *freight carriers* and *passenger carriers,* although most passenger carriers carry freight also. In time of war they may carry guns, usually for defensive purposes only. They are never armored. While a first-class passenger steamer will cross the ocean at a speed of from 2 to 25 knots, the average "tramp" makes from 8 to 11 knots only; economy of fuel and personnel being of the first importance to such ships, although the "tramp" appears to be disappearing, her place taken by the motor cargo ship; the competition for ocean-borne commerce being so keen that regular lines can provide for these cargoes. The interior arrangements and the division of space are determined by the necessities of the service; the handling and stowage of cargo being among the vital factors considered. In steamers carrying passengers, modern laws require that great attention be given to boats and other life-saving apparatus.

In merchant ships, as in men-of-war, watertight subdivision and integrity are vitally important. As merchant ships habitually, though not invariably, lie at a dock when in port, while men-of-war commonly ride at anchor, the sides of merchant ships are clearer of projecting obstructions than those of men-of-war, the guns of the latter alone proving an embarrassment in going alongside a dock or another vessel.

In 1926 the percentage of new construction fitted with motor engines had outstripped new construction with turbine installations.

Steamers fitted for burning oil increased from 1,300,000 tons in 1914 to 19,053,000 tons in 1928, while the percentage of coal-burning ships in ocean-borne commerce fell from 89 per cent to 61 per cent during the same period.

Many fine merchant ships have recently been built in shipyards of the United States such as the *S. S. California* (Plate **12**), and her sister ships the *S. S. Virginia* and the *S. S. Pennsylvania,* large passenger and cargo-carrying vessels in the New York to San Francisco trade via the Panama Canal. Characteristics of the *California* are: 613 feet long, 80 feet beam, 34,000 tons displacement, designed to carry over 800 passengers, capacity to carry 8,500 tons of perishable and non-perishable freight, speed about 18¾ knots, enabling her to make her run in 14 days with sufficient fuel to make a round trip.

The American Congress has lately enacted legislation to further develop an American Merchant Marine and to assure its performance in the transportation of the foreign trade of the United States, by extending aid in the form of direct subsidy to citizens constructing ships to be registered under American laws, and under specifications and plans approved by the Secretary of the Navy "for economical conversion into a naval auxiliary." This aid supersedes the former "mail carrying" subsidy which has been discontinued.

Sailing Ships. The United States operates by far the greatest tonnage of sailing vessels. Under similar conditions, as existed during the World War, there is no doubt but that the sailing vessel will reappear in greater numbers, but in times of peace there is but limited employment for this type. The full rigged ship is no longer economical (as compared with other sailing ships) due to the expense of handling the heavy sails and rigging.

There are routes today where the sailing vessel can make money, or at least can hold her own, such as in the lumber trade in the Pacific, and in certain other trade routes where the conditions are peculiarly favorable for such operation.

"The coming sailing vessel of the future, however, is the auxiliary; no matter what her rig may be. A vessel with crude oil engines, placed aft for convenience, offers a decided advantage to navigators and one that is beginning to be appreciated. Internal combustion engines take up a certain amount of hold space, to be sure, but the advantage gained through being able

© *Courtesy of the Panama Pacific Line.*

S. S. CALIFORNIA IN GAILLARD CUT, PANAMA CANAL.
(May be converted into Merchant Auxiliary Cruiser in time of war.)

to make headway in all kinds of weather should not be undervalued." [3]

Limitation of Naval Armament.

Inasmuch as at the present writing (January, 1937), all agreements as to naval armament limitations have just expired, only brief mention will be made of these agreements.

The first attempt at limitation of naval armament was initiated by the United States and resulted in the Washington Conference of 1921. The United States, Great Britain, Japan, France and Italy were represented at this Conference and all of these nations ratified the treaty which resulted in limiting the total capital ship displacement tonnage of the respective powers in the order listed above in the ratio of 5 : 5 : 3 : 1.75 : 1.75. Also, individual capital ships were limited to 35,000 tons standard displacement and to guns not exceeding 16 inches in caliber. Vessels other than capital ships were limited to guns not in excess of 8 inches in caliber.

To further the work begun by the Washington Conference, representatives of the United States, Great Britain, Japan, France and Italy met in London in 1930 and signed a treaty which became known as the London Conference of 1930. This Conference sought to limit the total tonnages of cruisers, destroyers and submarines. France and Italy could not come into agreement on these points and hence limitation of those types did not apply to them. Main points reached at the Conference were: replacement of capital ships postponed until after 1936; provided for the scrapping of capital ships so that the United States and Great Britain would each have fifteen, and Japan nine; limited the size of submarines to 2,000 tons and their guns to a caliber not in excess of 5.1 inches; provided for the limitation by December 31, 1936 of the cruiser, destroyer and submarine tonnage of the United States, Great Britain and Japan; established age limits for the replacement of ships other than capital ships.

[3] Captain C. T. Larsen in *Standard Steamship for the Merchant Service,* by Felix Riesenberg, D. Van Nostrand Co., Inc., as quoted from the *Marine Review* of August 20, 1920, in an article by Mr. Fred B. Jacobs. For a complete study of the ships of the merchant service and its seamanship there is no better work than that by Riesenberg and his *Preface* is a masterpiece that should be read by all seamen.

Both the Washington Conference and the London Conference expired on December 31, 1936.

The only agreement that can be said to be in effect at the present time as regards naval armament is an agreement among the United States, Great Britain and France which was concluded in London during 1936 but which has been ratified, so far (January, 1937), only by the United States. This agreement is to the effect that each country will keep the other advised as to what ships each country intends to lay down and what armaments such ships will have.

CHAPTER II.

THE HULL AND FITTINGS OF A SHIP.[1]

The principal parts of the hull of a modern ship are named below, and the locations of many of them are shown on Plate **13.** This is a view of the midship section of a battleship.

The Keel in a large ship is usually composed of the outer keel, the inner keel, the vertical keel and the middle strake of the inner bottom plating, called the keelson, with their accompanying angle bars. In some merchant ships a vertical outside keel, or bar keel, is fitted. At its forward end the keel joins the *stem*, which is of great strength, and its after end joins the *stern-post*, also very strong and arranged to carry the *propellers* and *rudder*.

To the keel are attached the *frames*, built up of main frame bars, floor-plates, and reverse-frame bars, all of which are strengthened and stiffened by *longitudinals* of various types. To the framing, the outside or shell plating is secured, the *garboard strakes* being adjacent to the keel plates and the *sheer strakes* being adjacent to main or upper deck beams.

An *inner bottom* is fitted on all large ships; this extends up the ship's side to the armor shelf on some armored ships, and to the margin plates on other vessels.

It is subdivided into small compartments by water-tight floors and longitudinals, so that leakage is reduced to a minimum if the outer shell is damaged. The frames near the bow and stern are sometimes spaced more closely than elsewhere to provide

[1] This chapter was revised in the 9th Edition by Lieutenant Commander Theodore L. Schumacher (C.C.), U. S. Navy. Very little change has been made in this revision except for new plates and addition of material on principal divisions of ships and numbering of compartments and decks.

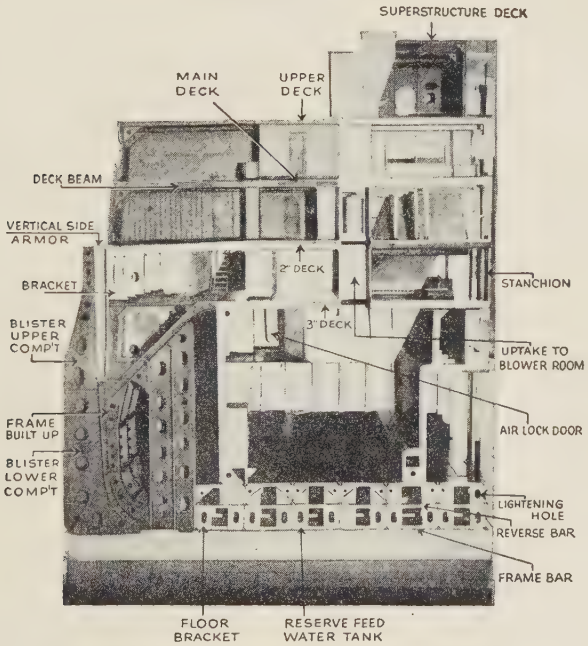
For those who would go into the subject more fully, it is recommended that the excellent text book, "Principles of Warship Construction and Damage Control," the official text book in use at the U. S. Naval Academy, be consulted. The authors of the above book are Lieutenant Commander George C. Manning (C.C.), U. S. Navy, and Lieutenant Commander Theodore L. Schumacher (C.C.), U. S. Navy. It is published by the U. S. Naval Institute, Annapolis, Md.

local strength, and *breast hooks, panting stringers, transom plates* and *counters* are fitted for like reasons.

Bulkheads are used to subdivide the ship's interior vertically into water-tight compartments for the preservation of buoyancy and stability; oil-tight bulkheads are fitted to form the necessary fuel oil tanks, and non-water-tight bulkheads are fitted to provide stowage and living spaces where water-tightness is not essential.

Principal Divisions of United States naval vessels are lettered

Plate No. 13



MIDSHIP SECTION OF A BATTLESHIP.

A, B and C, from forward aft. Division A comprises all of the space between the stem and the forward transverse bulkhead of the forward machinery compartment. Division B comprises all of the space between the forward transverse bulkhead of the forward machinery compartment and the after transverse bulkhead of the after machinery compartment. Division C comprises all of the space aft of the after transverse bulkhead of the after machinery compartment. (Certain older types of ships

are divided into four main divisions, lettered A, B, C and D, where B comprises the space between the forward transverse bulkhead of the forward boiler compartment and the forward transverse bulkhead of the forward engine room, and C comprises the space between the forward transverse bulkhead of the forward engine room and the after transverse bulkhead of the after engine room.)

The term machinery compartment shall be construed as meaning boiler rooms, engine rooms and compartments in which auxiliaries of the main propelling machinery are located.

These divisions shall be considered as extending from the keel to the highest deck in the line of bulkheads, or the bulkheads prolonged. In case the bulkheads do not extend to the highest deck, any spaces between decks that extend through two of the principal divisions shall be numbered as described in the case of a compartment situated entirely in the forward division of the two in which it is placed, and shall have this number alone.

All compartments are numbered, numbers in each division beginning at the forward end of that division. Compartments on the starboard side of the ship have odd numbers; those on the port side, even numbers.

For example, a ship that has a superstructure, forecastle, main, second and third deck, and a first and second platform deck, the compartments and spaces would be numbered as follows:

On superstructure deck	0101–0199
On forecastle deck	01–099
On main deck	101–199
On second deck	201–299
On third deck	301–399
On first platform	401–499
On second platform	501–599
In hold, if there are no more platforms	601–699

Double bottom compartments are numbered from 901 to 999. (On some of the older type of vessels, the above system of numbering is not strictly followed, various systems being in use.)

Decks are used primarily to provide shelter, working spaces and living quarters; and secondarily to subdivide horizontally the hull into a still greater number of water-tight compartments. Those used for the latter purpose are of steel, and may or may

not be covered with planking or linoleum. Other decks may be planked and calked only; but in this case, deck stringer plates and tie-plates are used to stiffen the deck beams. Deck beams are supported by stanchions, giving the decks support additional to that afforded by the bulkheads, and are fastened to the frames by means of beam arms or beam knees. In addition to providing subdivision, decks are absolutely necessary to ensure the ship's structural strength, both longitudinally and transversely.

To secure accessibility to all parts of the ship, numerous hatches, doors, scuttles and manholes are provided; these are water-tight where necessary, and those on the upper decks are always fitted for *battening down* to prevent the entrance of water to the interior of the ship in the event of the decks being swept by heavy seas.

All ships are subject to damage by collision and grounding. Under present conditions it may be said that all ships in time of war are subject to damage from underwater attack. Further, warships and other vessels used for belligerent purposes are subject to attack by gunfire and aerial bombs.

The following nomenclature of decks shall be followed for United States naval vessels. (From Bureau of C and R Manual.)

1. The highest deck extending from stem to stern shall be called the "main deck."

2. A partial deck above the main deck at the bow shall be called the "forecastle deck"; at the stern "poop deck"; amidships, "upper deck."

3. The name "upper deck," instead of "forecastle deck" or "poop deck," shall be applied to a partial deck extending from the waist to either bow or stern.

4. A partial deck above the main, upper, forecastle, or poop deck and not extending to the side of the ship, shall be called the "superstructure deck."[1]

5. A complete deck below the main deck shall be called the "second deck." Where there are two or more complete decks below the main deck they shall be called the "second deck," "third deck," "fourth deck," etc.

[1] The Bureau of Construction and Repair interprets this as meaning that a deck structure, although extending to the line of the ship's side is not an upper deck unless the side plating of the ship is carried up and connected to it.

6. A partial deck above the lowest complete deck and below the main deck shall be called the "half deck."

7. A partial deck below the lowest complete deck shall be called the "platform deck." Where there are two or more partial decks below the lowest complete deck, the one immediately below the lowest complete deck shall be called the "first platform"; the next shall be called the "second platform," and so on.

8. Decks which for protective purposes are fitted with plating of extra strength and thickness shall be further defined, for technical purposes, as "protective" and "splinter," in addition to their regular names. Where there is only one such deck it shall be defined as "protective" and where there are two, that having the thicker plating shall be defined as "protective" and that having thinner plating shall be defined as "splinter" in addition to the regular names.

9. Where a protective deck is stepped a complete deck height, the respective portions shall be distinguished by means of the terms "middle protective section" and "forward (or after) protective section" in addition to the regular names. Where a splinter deck is stepped a complete deck height, the respective portions shall be similarly distinguished.

10. Where a portion of the protective or splinter deck is sloped, the sloping portion shall be defined as the "inclined protective deck" or "inclined splinter deck."

Protection against underwater damage due either to grounding, collision or underwater explosion, is primarily afforded by minute watertight subdivision of the ship's hull. This protection varies from that found in the smaller and cheaper cargo vessels to the latest type of capital warship. In the former the protection is meager, consisting only of a double bottom and the placement of the main bulkheads so as to limit, as much as possible, flooding due to damage. In the larger freighters and passenger vessels the protection is much more extensive and is afforded by closely placed watertight decks, and athwartships and longitudinal bulkheads, in addition to double bottoms. In battleships and, to a lesser extent, in the smaller warships, such as cruisers, the protection is as complete as possible and is primarily afforded by an extremely minute watertight subdivision of the interior of the hull even to the point of, for example, placing each boiler in a separate watertight compartment.

Protection against gunfire and aerial bombs is not properly provided for in any type of ship except the battleship. Some protection is provided on the smaller warships, however. On a battleship the protection consists of an armored box fitted around that part of the ship which is just above the waterline. The bottom of the box is the lower armored deck. This is just below the waterline and over the boilers, engines and magazines. The top of the box is the upper armored deck which is the deck next above the lower armored deck. The sides of the box are formed by the main armor belt secured to the ship's side and the ends of the box are the athwartship armor belts which cross-connect the two ends of the main armor belt. With this arrangement any attack by shellfire, before it reaches the vitals of the ship, must first pierce either the main armor belt or the upper armored deck and then must also pierce the lower armored deck. Aerial bombs dropped on the ship must, of course, before they reach the vitals, pierce both armored decks. In addition to the above protection, battleships are afforded protection to the guns chiefly in the form of armored turrets and to other vitals above the main armor such as the conning tower (battle control station), uptakes, ammunition supply, etc.

Ventilation is provided to secure a circulation of air within the hull's interior and to replace foul air by fresh air taken from the outside atmosphere. Natural ventilation is provided by cowls and windsails, which, when trimmed to the wind, send fresh air below to replace foul air which is forced outboard through hatches, airports, etc., or through exhaust cowls which are trimmed from the wind to increase the rapidity of air circulation. Artificial ventilation is provided by electric blowers, which drive fresh air from outboard and discharge it through ducts and louvres into the ship's interior; or which draw foul air from the interior and discharge it outboard.

In large ships, both of these artificial systems are frequently combined; one set of blowers supplying fresh air, and another set exhausting foul air. In all ships, natural ventilation is extensively provided, and careful attention to apparently small details is necessary to secure efficient circulation.

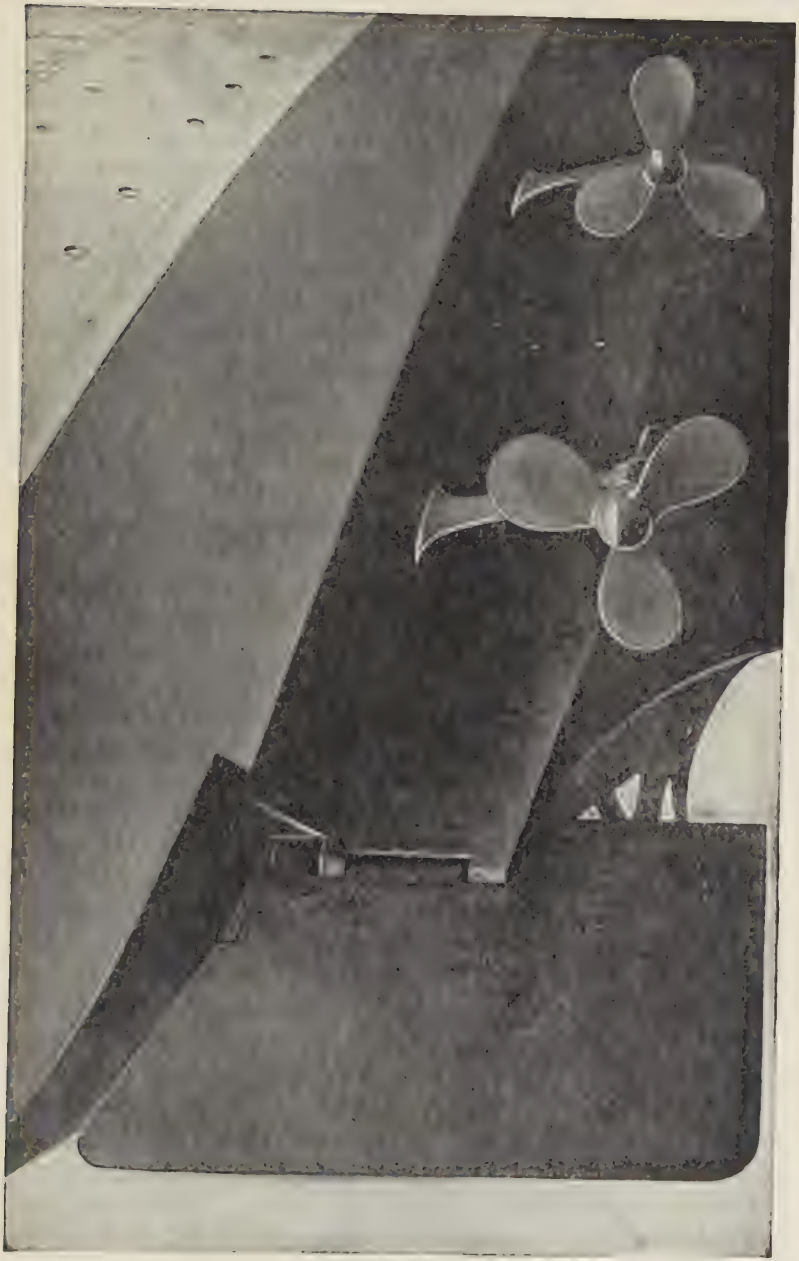
In modern ships the ventilation is accomplished by means of a large number of independent systems so distributed that watertight bulkheads are seldom pierced by the piping.

Earlier ventilation systems provided cold air only. Later ships are equipped with combined heating and ventilating systems for living spaces. Attempts are made to include in the design means of reducing to a minimum the dangers of gas being introduced into the system.

Drainage. To provide for the removal of large quantities of water from the bilges, the main circulating pumps are provided with bilge suctions in the engine rooms. Boiler rooms have independent motor-driven pumps with independent outboard discharges. The pumps are of the centrifugal type and are capable of operating submerged, as the motors for driving them are placed on a higher deck-level than the pumps, and the valves opening into the sea-valves can also be operated from a higher deck.

There is also a *secondary drain* connected to numerous pumps, which enables small quantities of water to be removed from any compartment in the following manner: A metal chest called a *manifold,* containing a number of suitable valves, is located in a convenient position. One of these valves is connected by piping to an adjacent pump, another to the secondary drain, another to the sea, and each one of the remainder to some particular compartment above or within the double bottoms. To remove water from any compartment containing water, it is only necessary to open the valve connecting the compartment with the manifold, and the valve connecting the manifold with a convenient pump, and then to operate the pump.

The Firemain usually consists of a lead-lined steel pipe running fore and aft nearly the whole length of the ship, and placed, on warships, underneath an armored deck. It is connected to the fire and bilge pumps and is maintained full of water at a pressure of one hundred pounds per square inch. Numerous branches are located in suitable positions on the various decks, to which are attached hose plugs to furnish water for fire and wash-deck purposes. The various upper outlets are connected by vertical branches or risers to the firemain below the armored deck, each having a stop valve by which it may be cut off from the rest of the systems; so that any one set of outlets may be disabled without disabling the others. Fire hose ready for instant use is stowed near each plug. The salt water required for flushing the heads and lavatories is sometimes supplied from the firemain



STERN OF A BATTLESHIP.

direct, and sometimes by a separate system of flushing pipes which are filled by certain special steam and hand pumps.

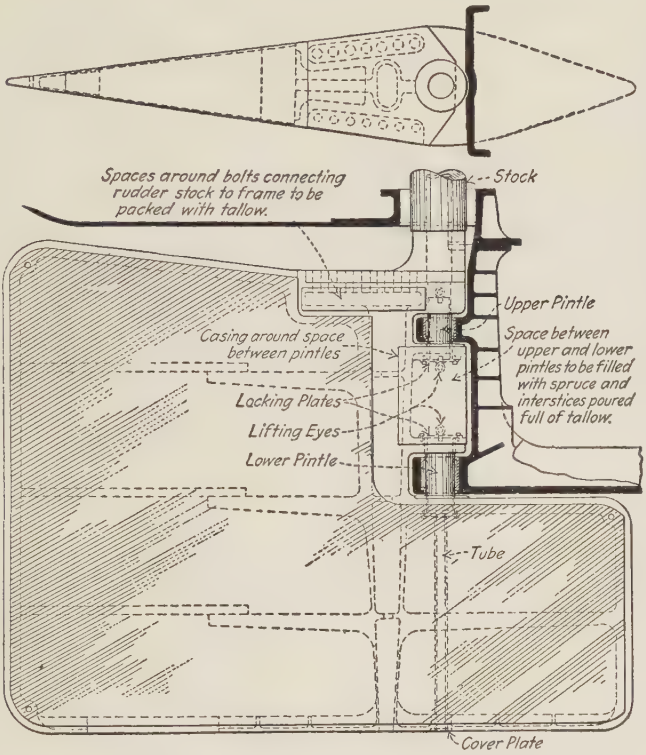
The **Sanitary** and **Flushing System** provides a supply of salt water for use in toilets, washrooms, laundries, galleys, sick bay, etc. In a battleship, the *flushing main* is about six inches in diameter and is carried underneath the second deck beams, being supplied by risers from the sanitary pump and cross-connected to the fire and bilge pumps. Branches as required lead to the various compartments. The crew's lavatories are often flushed by an independent system supplied by motor-driven pumps.

Fresh Water for use in the boilers and for drinking purposes is carried in tanks which are structural compartments of the hull, which can be filled from shore, from water boats, or from the ship's own distillers. For a battleship with a crew of 1,000 men, the capacity of the evaporating and distilling plant is about one hundred tons of fresh water every twenty-four hours.

Magazines are flooded when necessary through pipes connected to the sea, one or more flood cocks being provided in each ammunition room, so arranged that they can be opened from the handling room space and also from an upper deck. Ships also have sprinkler systems connected to the firemain for sprinkling the magazines.

Propellers for warships (Plate **14**) are generally of the three-bladed type, while for merchant ships, four blades are generally used. The three-bladed propeller is lighter and of higher efficiency, but many engineers prefer the four-bladed propeller on account of the reduced tendency to vibration in rough water. Propellers for high-speed turbine installations are characterized by their small diameter. Propellers are now ordinarily made of manganese bronze, as more strength and a much better surface can be obtained with this material than with cast iron or cast steel. When bronze propellers are used, however, it is generally necessary that zincs be fitted to the ship's hull in their vicinity to prevent galvanic action upon the steel of the hull.

The Propeller Struts are used for supporting the propeller and tail-shaft outside the hull, and in recent ships are of pear-shaped or oval section to diminish the resistance to their passage through the water. In addition to having this shape of section, the longitudinal axes of the strut-arms are placed in the path of the


Spaces around bolts connecting rudder stock to frame to be packed with tallow.
Stock
Upper Pintle
Space between upper and lower pintles to be filled with spruce and interstices poured full of tallow.
Casing around space between pintles
Locking Plates
Lifting Eyes
Lower Pintle
Tube
Cover Plate

UNSHIPPING OF RUDDER

1. Remove casing around space between pintles and turn hard over.
2. Remove filling, locking plates, & lifting eye from lower pintle.
3. Drive down upper pintle (thru hole in stock) and support same by blocking when attaching sling for removal.
4. Reinsert lifting eye in lower pintle, remove cover plate, and drive up lower pintle thru tube provided for this purpose. When raised about 9" remove eye bolt, and raise and remove by sling fitted around exposed part of pintle.
5. Block up rudder, and remove upper bearing and stuffing box on sternframe after dismounting crosshead, etc.
6. Swing rudder aft as far as possible and lower at the same time.

FIG. 1. RUDDER OF A BATTLESHIP.

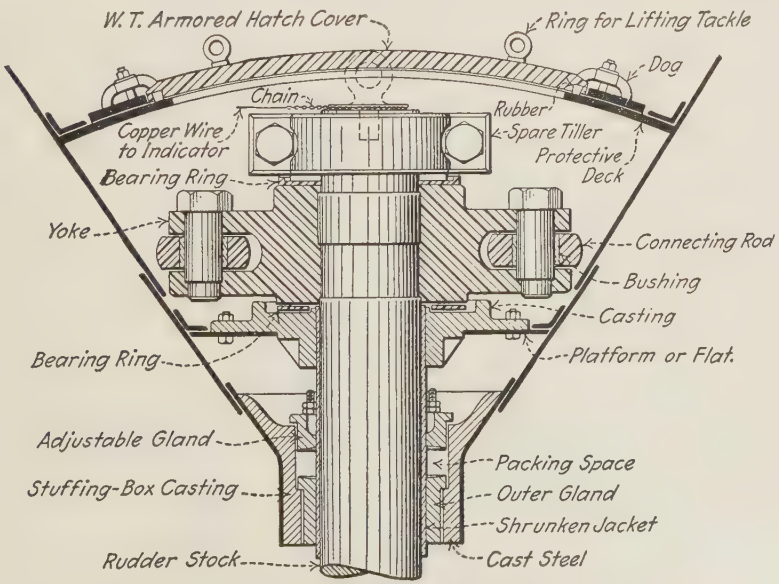


FIG. 2. SECTION THROUGH RUDDER STOCK.

stream-lines at the stern of the ship, to still further decrease their resistance.

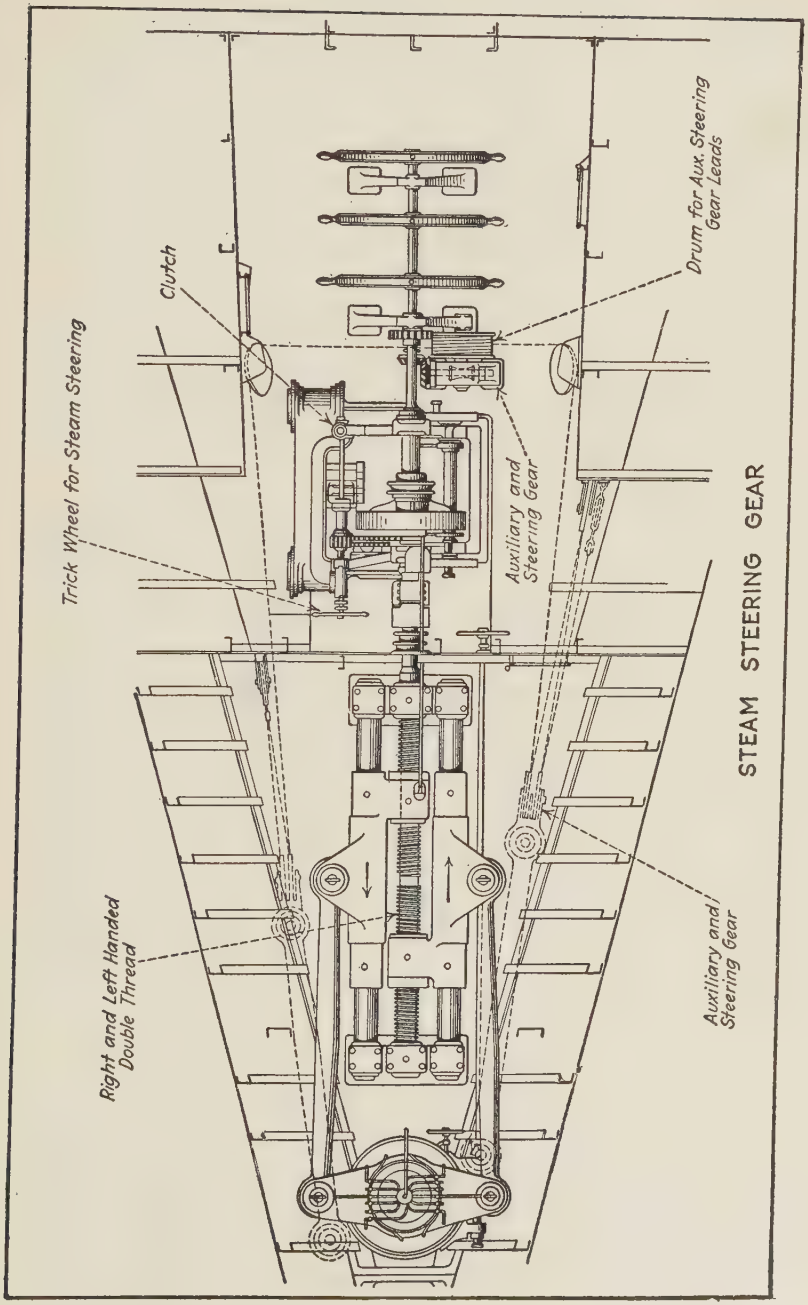
Steering Gear. The *rudder* of a warship (Plates **14 and 15**) is unusually large and the steering gear unusually strong, in order that such a vessel may be under more perfect control than is considered necessary in merchantmen. The *rudder-stock* is made of special forged steel, its size depending upon the speed and size of the ship and the rapidity with which it is necessary to put the rudder hard over when the ship is at her maximum speed. The *rudder-frame* is usually of cast steel, which is filled in with wood and covered with steel plating. The weight of the rudder is taken on a suitable carrier within the ship, firmly supported by the hull structure and so arranged that the stuffing box and gland attached to the rudder-post casting may be accessible.

The *rudder* is attached to the *stern-post* by "pintles" and "gudgeons" in such a way that it can be unshipped in drydock. The pintles are forged pins on the forward edge of the rudder. The gudgeons are the lugs on the after side of the stern-post into which the pintles are engaged.

Rudders may be either *balanced* or *unbalanced*, the balanced type being used principally on larger vessels. When a balanced rudder is put over, the water pressure on the part forward of the rudder-post acts with the tiller and greatly reduces the power required to put it over and to hold it in position. (Plates **14**, **15**.)

To the *rudder head*, the *rudder cross-head* or the *tiller* is firmly secured. Sometimes both are fitted.

It frequently occurs that the run of the ship is so fine that it is necessary to fit a secondary cross-head placed forward, in order to provide space for the steering gear and its connections, the two cross-heads being connected by suitable rods. It is not uncommon, where space permits, to use a straight tiller or quadrant which is connected to the steering mechanism by chain or wire rope. The rudder is thus turned through an angle of about 35 degrees on each side of the centre line, hard-over stops being fitted to the rudder post and the rudder frame to limit the amount of travel should accidents occur to the steering mechanism. The motive power is usually steam, hydraulic or electric, hand power being always provided for use in cases of complete breakdown.


STEAM STEERING GEAR
Trick Wheel for Steam Steering
Clutch
Drum for Aux. Steering Gear Leads
Auxiliary and Steering Gear
Right and Left Handed Double Thread
Auxiliary and Steering Gear

Where a rudder cross-head is used (Plate **16**), the engine turns a shaft having a right- and left-handed thread which drives two nuts connected to the cross-head by side rods. By turning the engine in one direction the nuts recede from each other and the cross-head turns in one direction, and by turning the engine in the reverse direction, the nuts approach each other and the cross-head is turned in the reverse direction.

With quadrants and tillers, the chain or wire rope is wound around a drum which can be turned in either direction, suitable provisions being made to prevent any slack occurring.

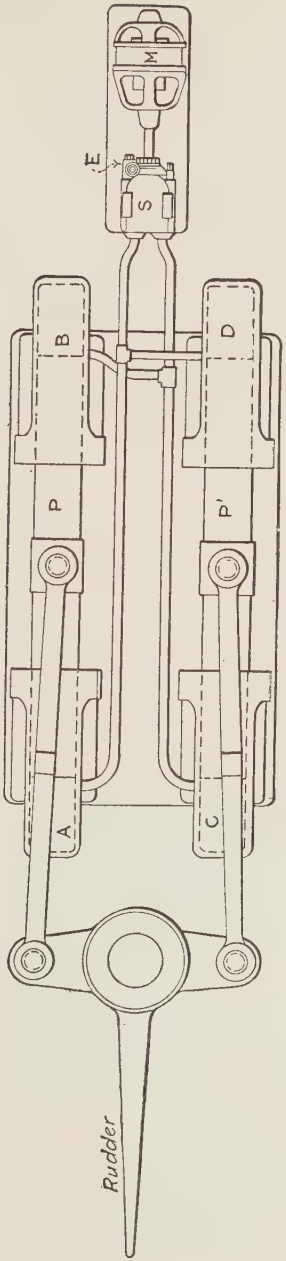
The hand gear consists of steering wheels of large size located in various parts of the ship, which by shafting, chain, or wire-rope, operate the rudder in the manner shown on the plans.

Arrangements are provided for shifting quickly from power to hand gear, and from hand to power.

Steering wheels are usually provided in the conning-tower, in the "Central Station," and on the bridge; and where practicable are arranged with clutches so that any one wheel can be turned without turning the others. From the conning-tower stand, a steel rod extends downwards through the armored tube and below the protective deck, where it rotates a transmission drum, which in turn rotates a second drum located in the steering room, the two being connected by the steering rope. The valve controlling the admission and exhaust of steam or water is automatically operated by the transmission drum so that the rudder is turned whenever the helmsman turns the power steering wheel, and remains stationary at any angle when the wheel is kept stationary at the corresponding position, the rudder indicator showing at each instant the actual position of the rudder. Various electric and hydraulic appliances are also used to accomplish these same purposes.

Electro-Hydraulic Steering Gear.

The electro-hydraulic steering gear consists essentially of a hydraulic steering gear of the usual type which takes its supply of operating fluid from a variable stroke pump connected to a continuously running electric motor, instead of taking its supply from a constant pressure source, such as the ship's hydraulic



DIAGRAMMATIC PLAN OF MAIN STEERING GEAR
U.S.S. NEW MEXICO

mains or an accumulator supplied by steam pumps. A diagrammatic plan of this type steering gear is shown in Plate No. **17**.

The steering gear for the latest designed capital ships of the United States Navy (*Saratoga* and *Lexington*) consists of hydraulic rams directly connected to the rudder and operated by motor-driven variable-stroke pump equipment.

The Telemotor is a device for furnishing a connection between the steering engine and the steering wheel, such that the wheel shall not only control the engine but indicate at all times the position of the rudder. In vessels of early design this connection was made by wires, chains, or shafting, with a complicated lead which involved many joints and turns. In the telemotor, the connection is sometimes electrical but more often hydraulic.

In some ships the Telemotor System is doubled throughout so that in case one line of piping is out of commission the other may be used.

The hydraulic telemotor used in battleships of latest design is shown on Plate **18**.

Fig. 1 shows the vertical section of a pump, *A*, fitted with the usual piston, *B*, which is moved up and down by a rack, *C*, into which gears a pinion, *D*, the shaft of which is made to revolve by the wheel, *F*, the pinion, *G*, and the hand-steering wheel. The cylinder *A*, when the piston is where shown on the drawing, *i.e.*, in mid-position, admits of a free passage of water above and below the piston, so that there are two cylinders, the upper one and the lower one.

From the by-pass valve, *S*, which is connected to the top of cylinder by pipe *H*, and directly to the lower cylinder, two pipes, *H* and *I*, Fig. 1, pass and join up to a cylinder *K*, Fig. 3. These pipes correspond to pipes *M* and *L*, Fig. 3. The cylinder *K* is fitted with a piston *N* and with the usual piston rod and connecting link *O*, which is attached by a lever to the follow-up mechanism of the steering engine. The piston rod has crossheads *P* and *P*, between which are two spiral springs, *Q* and *Q*, the object being to cause the piston end to fly into mid gear, unless put out of that position by pressure of water on either side.

As the diameter of the cylinder on the bridge is in every respect the same as that aft, it follows that when the apparatus is fully charged with fluid, any movement of the steering wheel will bring about a similar movement of the aft-motor-piston and the valve gear of the steering engine. In putting the wheel over, it will be felt to become sensibly stiffer until it is hard over, and on letting go it will run back of its own accord amidships.

The telemotor on the bridge is fitted with an indicator shown in Fig. 2, which shows the actual position of the rudder.

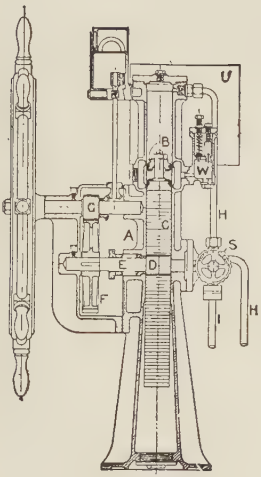


FIG. 1

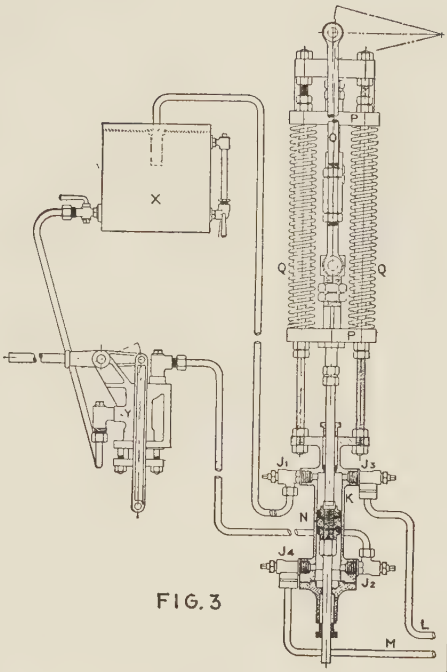


FIG. 3

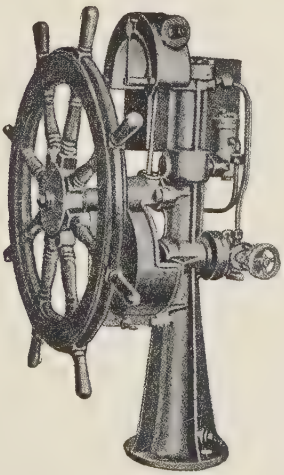


FIG. 2.

TELEMOTOR.

The Preservation of Ships.

Rust. In order properly to preserve the steel structure of a ship from corrosion, or wasting away, means must be provided for preventing the formation of *rust.* The rusting of steel or iron is the combination of oxygen and iron, this combination being caused by the presence of carbon dioxide in the moist air or water to which the metal is exposed. The carbon dioxide acts upon the iron to form a carbonate, which, in turn, unites with oxygen to form iron rust and new carbon dioxide, and this latter feature accounts for the continuation of the process of rusting, as the new carbon dioxide attacks new iron, causing the process to go on until no more iron remains.

The formation of rust is accelerated by heat, as is commonly evidenced by the fact that the portions of the ship's hull near the boilers rust much more rapidly than others; in fact, if the heat is sufficiently great, the iron will oxidize without the presence of moisture. A hot, steamy atmosphere, therefore, is especially conducive to rusting; and consequently, portions of the ship which are exposed to such an atmosphere require special care and attention.

The best preventive of the formation of rust is to provide a coating, such as paint, bitumastic, cement, etc., which shall be impervious to moisture. Some details of these preventives will be given later.

Galvanic Action. The corrosion of a ship's structure is also caused by *galvanic action,* an electrical phenomenon which takes place when two dissimilar metals are placed in an acid in metallic contact with each other. An electric current is then set up between the two metals which flows from the *electro-positive* metal to the *electro-negative* metal, and which results in the corrosion of the former. Salt water has the effect of a weak acid upon two dissimilar metals; consequently galvanic action will occur between the different metals comprising the ship's structure wherever they are in contact with sea or bilge water, etc., and will cause corrosion of the electro-positive metal. Galvanic action between copper, bronze, lead, and steel results in the corrosion of the steel; that is, the steel is electro-positive to the others; but galvanic action between zinc and steel results in the corrosion of the zinc, this being electro-positive to steel.

Mill Scale, formed by the application of water to hot steel while it is being rolled at the mill, is an oxide of iron; and as steel is electro-positive to this scale, it will be seriously corroded if the scale is not removed. This removal can be effected by *pickling* the steel in a weak acid solution, so that the scale becomes loosened and can then be brushed off. Another method is to leave the steel exposed to the weather for some time and allow ordinary rusting to loosen the scale a sufficient amount so that it can be removed by wire brushes.

Steel is also electro-positive to ordinary *rust scale,* so that the presence of rust upon steel tends to increase the corrosion of the steel when it is immersed in salt water. It is very evident, therefore, that all possible means should be taken to remove mill scale and rust scale before the steel hull is painted; otherwise the presence of moisture in the scale will cause galvanic action, with the consequent pitting of the steel and blistering of the paint, resulting in the formation of *rust cones.* If the steel plating is thoroughly dry before painting is done, the chances of corrosion are, of course, greatly lessened.

Not only do different metals cause galvanic action, but it is also true that different grades of the same metal may be subjected to corrosion from galvanic action. In general, the softer, or low-carbon material, suffers the most from corrosion due to this cause. Experience has also shown that steel ships suffer much more from corrosion than iron ships do.

The corrosion of the steel hull by galvanic action may be reduced by the use of *zinc protectors.* These consist of unpainted slabs of rolled zinc, and they are fitted to stern-posts, rudders, strut hubs, etc., when bronze propellers, or other bronze fittings are used, so that the galvanic action which is set up between the bronze and the zinc will corrode the zinc, this being more electropositive to bronze than is the steel of the hull. As soon as the zinc protectors are badly eaten away, they must be renewed.

The practice of fitting zinc protectors on the steel plating of the hulls of vessels, in the vicinity of composition sea valves and chests, and composition torpedo-tube mouthpieces, as a protective measure against electrolytic action, has now been abandoned except on submarines and destroyers. Protectors of steel have been substituted for zinc.

Anticorrosive Coatings. There are several distinct varieties of coatings for preventing corrosion; viz., paint, varnish, oil, bituminous compositions, cement, galvanizing, etc., and they are used for different parts of the ship's structure depending upon the various conditions. (Bureau of C & R Manual for details.)

Painting is by far the most commonly used method of preventing corrosion; and if all parts of the ship could be kept well coated with paint, there would be practically no danger of corrosion. It is only when paint loses its protective qualities through age or wear, that the metal becomes subject to corrosion. *Paint, or other coatings, should never be applied to damp, oily, or greasy surfaces, or to surfaces which have not been thoroughly scaled and cleaned, and each coat of paint should be allowed to dry before the next coat is applied.*

Red Lead has a more extensive use than any other paint. It is used as a priming coat on the entire outer surface of the hull and all metal surfaces exposed to the weather; on all inside work (except metal to which special paint, cement, or oil, or bituminous compositions are to be applied); and on plating behind armor. Red lead has been found by experience to have practically no injurious effect upon steel, and it has excellent adhesive, wearing and covering qualities. Aluminum paint is now used in many cases as a priming coat instead of red lead in certain compartments aboard ship.

Ships' Bottom Paints. In addition to the priming coat of red lead applied to the bottom of a steel ship, special paints are also used to prevent corrosion and fouling. A great number of these special paints have been tried from time to time; but in the United States Navy the only bottom paints now used are the standard *anticorrosive* and *antifouling* paints manufactured at the navy yards. The purpose of the anticorrosive paint is to prevent corrosion by separating the metals contained in the antifouling paint from the steel itself. The purpose of the antifouling paint is to prevent fouling of the ship's bottom, oxides of mercury and copper being used as an ingredient to destroy any marine growth which may attach itself to the bottom of the ship. Care should be taken when applying this paint that it does not come in contact with the steel plating; otherwise it will cause corrosion.

Anticorrosive and antifouling paints should always be applied just prior to launching or before undocking; and in general, two

complete coats of anticorrosive and one complete coat of antifouling paint are applied. When a ship is docked it is not customary to touch up or paint the bottom with red lead, but the anticorrosive paint is applied directly over any red lead found firmly adhering to the steel, or else to the bare metal. Antifouling paint should always be applied just before a ship is put into the water, for the reason that if it is allowed to stand exposed to the air for a period of twenty-four hours or more, it begins to lose its antifouling properties.

Wooden hulls, such as those of submarine chasers, tugs, lighters, etc., are given two coats of an approved *copper paint* in order to prevent fouling, and larger wooden ships and ships having wooden outside planking are *sheathed* with sheet copper for the same purpose. Marine growths do not attach themselves readily to copper as it constantly gives off poisonous salts which tend to destroy them.

Boot-Topping Paint. The region of the hull between the light-load and the full-load water-lines is particularly difficult to protect against corrosion, for the reason that the anticorrosive and antifouling paints deteriorate more rapidly when exposed to air than when immersed in water, and moreover, the plating in this region is subjected to much more chafing than are other portions of the hull. Here a special, quick-drying paint, called *boot-topping,* is used, the principal ingredients of which are varnish and drier. For large ships, the band of boot-topping is four or five feet wide, and for small ships two feet wide.

Bituminous Compositions. It has been shown by experience that the most efficient coating for steel work in double bottoms, machinery spaces, fresh water tanks, and similar spaces is a material composed of coal tar, pitch, or asphalt. Bituminous composition, or "bitumastic," consists of *bituminous solution,* which is applied cold with a brush as a priming coat; and *bituminous enamel,* or *bituminous cement,* which are applied hot, over the solution. The cement is suitable for flat, horizontal surfaces, and is spread on with a thickness of at least one quarter of an inch, while the enamel is suitable for overhead, vertical, or inclined surfaces, and is applied to a thickness of at least one sixteenth of an inch.

Bituminous compositions should be applied only to surfaces which are *thoroughly dry and clean,* and *free from paint, oil,*

grease, or rust; and if practicable they should be put on when the ship is out of water. Artificial ventilation should always be furnished when bituminous compositions are being applied in confined spaces as their fumes are liable to overcome the workmen in their vicinity.

In many ships the inner surface of the shell plating is coated with *cement* to prevent corrosion, and also to prevent the wearing away of rivet heads and plating through the constant washing to and fro of the bilge water and the foreign substances sometimes contained therein. *Cement wash,* consisting of cement and fire clay, is applied with a brush to the inside of fresh water tanks as well as reserve feed water tanks, care being taken that the metal is thoroughly dry when the wash is applied.

Galvanizing is another method of preventing corrosion, and consists in thoroughly cleaning the metal in an acid bath, and then applying a coating of zinc, either molten (the hot process), or by electrolytic methods. It is used chiefly for protecting deck fittings, such as rails, stanchions, bitts, chocks, cleats, bolts, etc. It is also used, in addition to paint, for protecting the steel structure of destroyers, for the reason that the hulls of these vessels are built of such light material that only a small margin is allowed against corrosion.

Special Measures to Prevent Corrosion, U. S. Navy. Whenever a ship of the United States Navy is docked at a navy yard, the condition of the ship's bottom is examined by the Commandant's representatives and a complete report concerning this condition is forwarded to the Bureau of Construction and Repair.

In addition to the above, a "Hull Board" is always appointed by the commanding officer of every ship, and it is the duty of this board to examine and report upon the condition of every part of the ship as regards corrosion or deterioration, and to make such comment and recommendation as are pertinent to the subject.

Tonnage of Ships.

As there is sometimes confusion as to the difference between displacement and the several kinds of tonnage, the following definitions are given:

Displacement. The quantity or volume of water displaced by a ship is called her "displacement"; it can be expressed in either

cubic feet or tons; a cubic foot of sea-water weighs 64 lbs. and of fresh water 62.5 lbs., therefore a ton is equal to 35 cubic feet of sea-water or 35.9 cubic feet of fresh water.

Tonnage, Gross Register. The total enclosed space or internal capacity of a ship, *expressed in tons of 100 cu. ft. each,* is the gross register tonnage. The unit of volume is that figure which was used originally in "Moorsom's System" of measuring ships, which system has, with slight variations in application, been adopted by most of the nations of the civilized world.

Gross register tonnage is used as a basis for calculating net register tonnage in the United States as a basis for dry dock charges for steamers.

Tonnage, Net Register. The actual earning power of a ship is expressed by the net register tonnage and this figure is secured by deducting from the gross tonnage such spaces as may have no earning capacity; for instance, the engine, boiler and shaft alley spaces, coal bunkers, spaces used in steering and working the ship, and such spaces as may be necessary for the accommodation of the crew. The laws of the several nations vary with reference to the various deductible spaces. Net register tonnage is generally used in charging harbor dues, canal tolls, and other similar charges to which merchant ships are liable.

Load Line Markings.

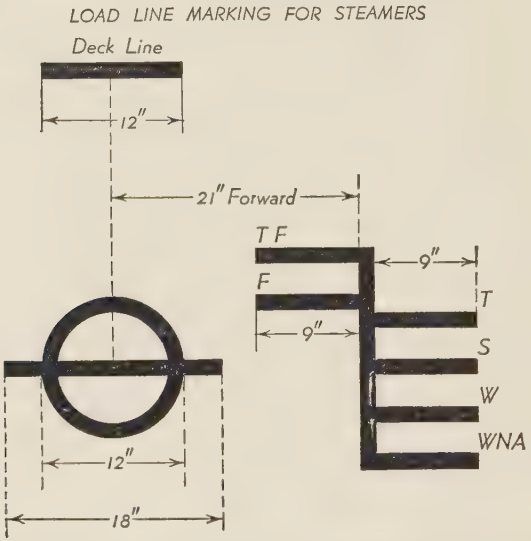
In accordance with the International Load Line Convention, 1930, and an Act of Congress passed in 1929, load lines were established for merchant vessels of 150 gross tons or over, proceeding to sea on an international voyage. (Special load lines for vessels engaged in voyages on the Great Lakes, and in Coastwise Voyages by Sea, are in conformity with the Coastwise Load Line Act, 1935, and apply also to all merchant vessels of 150 gross tons and upwards.) These load lines indicate the drafts at which for various conditions and types or classes of vessels, there will still be left a sufficient percentage of reserve buoyancy to insure the safety of the vessel. The position of this mark depends upon the type and size of the vessel. On it are indicated the maximum safe drafts for fresh and salt water, for winter and summer, and for certain oceans.

As provided in the Load Line Act of 1929, the American Bu-

reau of Shipping assigns load lines and issues load line certificates.

The authority by whom the load lines are assigned may be indicated by letters marked alongside the disc and above the center line.

Plate No. 19



Explanation of Symbols of the Load Line Mark. (Plate **19.**)

T F—Tropical Fresh Water Load Line.
F—Fresh Water Load Line.
T—Tropical Load Line.
S—Summer Load Line.
W—Winter Load Line
W N A—Winter North Atlantic Load Line.

All except the first two of the above symbols indicate the maximum depth in salt water for the corresponding oceans and seasons.

The center of the disc is to be placed on both sides of the vessel amidships; *i.e.*, at the middle of the length of the load water line. Vessels are to be marked with such of the horizontal lines as are applicable to the nature of their employment. The discs and the lines must be permanently marked by center punch marks or by

cutting, and the particulars given in the certificate are to be entered in the log.

The horizontal line passing through the center of the load line disc is the summer load line.

Steamers to which timber load lines are assigned are to be marked with an additional set of horizontal lines abaft the load line disc, indicating maximum timber load lines in different circumstances and different seasons. The lettering is the same as on the other lines except that an "L" is prefixed to each, such as "L T F," "L F," and so on.

A sailing ship is to be marked with deck line, load line disc and F and W N A lines.

CHAPTER III.

ROPE.

Introduction. The rope commonly used on shipboard is of the following kinds:

Manila, made from Philippine Abaca.

Tarred hemp, made from American hemp.

Wire, made principally from steel.

Lead lines and taffrail log lines, made principally of cotton.

Signal halliards, made of unfinished flax twine.

In addition to Abaca the following fibres are used to manufacture various fibre ropes used in commercial trade:

Canton, Pacol, Maquey and **Sisal.**

Hemp Rope. Hemp rope is made of fibres from the stalk of the hemp plant (Plate No. **20**), which is cultivated extensively in many parts of the world, but especially in Italy, Russia and the United States. American hemp is very generally used for cordage in the United States.

Hemp rope is now but little used. When used, it is almost invariably tarred. In this form it is used on shipboard for such of the standing rigging as is not of wire. The tar preserves the rope from deterioration due to dampness but reduces its strength and flexibility. Untarred hemp is the strongest fibre rope made except wire and is used aboard sailing yachts. In present United States Naval practice, tarred hemp is used only for "small stuff": ratline, marline, houseline, spun yarn, roundline, etc.

Manufacture of Manila Rope.

Manila rope has to a great extent displaced hemp for general purposes on shipboard. It is made from the fibre of the Abaca plant. The Abaca, which resembles the banana plant, is not a hemp as is commonly believed. It is a perennial plant, grown to a height of from ten to twenty feet and found principally in the Philippine Islands.

Fig. 1. The Hemp Plant.

Fig. 2. The Abaca Plant. (Manila Fibre.)

Fig. 3. Hemp Fibre.

Fig. 4. Manila Fibre.

ROPE FIBRES.

When ready for harvesting, the matured Abaca plants are felled and cut into slabs called "tuxies." Fibre extraction is then done by stripping the "tuxies" with a knife. Machines are being used to a certain extent for this, although previously all stripping was done by hand. The perfection and strength of the finished rope depends upon the thorough cleaning of the fibre during the stripping process. When the fibre is cleaned, it is spread out and thoroughly dried by sun and air. The fibre is then carefully sorted, classified and baled, and is now ready for the rope factory.

Taken from the bales, the fibres are combed smooth and straight by machine. At this stage an emulsion of oils is added to soften and lubricate the fibres. From ten to fifteen per cent by weight of the finished rope consists of oil, making for preservation against both excessive dampness and excessive heat.

The combed fibres are now spun into twisted yarns, wound on bobbins. In this connection it should be noted that in the U. S. Naval Service the terms "thread" and "yarn" are used interchangeably. The yarns are then twisted into strands by means of the bobbins and capstans. Three or four strands, each strand composed of a number of yarns twisted together, go to make the finished rope. This is accomplished in the laying machine. To counteract the tendency to unlay, the successive twists are taken in opposite directions, yarns being usually right-handed, strands left-handed and ropes right-handed.

Rope is commonly made with three strands, but four are sometimes used. Also left-handed rope may be produced by reversing the direction of the twists. Sometimes several ropes are twisted into a *cable*.

Small Cordage. Small cordage is usually known on shipboard as "small stuff," and designated either by the number of threads that it contains, as "12-thread stuff," "15-thread stuff," etc., or as "ratline stuff," "seizing stuff," "marline," etc. These are tarred hemp and are measured in some cases by the fathom, in other cases by the pound.

The following are the most common varieties of small-stuff used on shipboard:

Spun-Yarn. A rough and comparatively cheap stuff made from long tow and loosely laid up, left-handed, of two or three yarns. It is more used on shipboard than any other variety of

small-stuff, being convenient for seizings, service, etc., where great neatness is not required.

Houseline, Roundline and **Marline** are used for the same purposes as spun-yarn, but make neater work, being laid up more smoothly and of better material.

Marline and **Yacht Marline** are 2-stranded left-laid, **Houseline** 3-stranded left-laid, and **Roundline** 3-stranded right-laid. All of the above are used for seizings, but where a heavier and stronger material is needed, laid up by rope-making machinery and finished like the larger sizes of rope, although classed as small-stuff. This is called **Seizing Stuff.** It is usually 3-stranded, right-handed, and may have 2, 3 or 4 threads to the strand, making 6-thread, 9-thread, or 12-thread seizing stuff.

Ratline Stuff does not differ from seizing stuff in its general characteristics, but is larger. It is 3-stranded, right-handed, and may have 4, 5, 6, 7, or 8 threads to the strand, making "12-thread," "15-thread," Ratline Stuff and so on.

Size of Fibre and Wire Rope. Fibre rope is designated as to size by its circumference, and runs from about five-eighths of an inch to sixteen inches and even more. However, the largest sizes are never seen on shipboard, twelve inches being about the maximum that even the largest ship would carry. The length is measured in fathoms, for shipment it is made up in coils. (Plate **21.**)

Manufacturers commonly designate the size of wire rope by the diameter and this designation is used in the U. S. Naval specifications. Nevertheless, some seamen adhere to the habit of designating it by circumference and the circumference is used to determine (rule of thumb) safe working load and breaking strain. For this reason it is well to take the precaution of stating whether the size mentioned represents diameter or circumference. Wire runs from about one quarter inch to two and three quarters inches in diameter.

WIRE ROPE.

Wire Rope (Plate No. **22**) is made of steel or occasionally iron wires laid up like yarns to form strands, which strands are in turn laid up to form a rope. The characteristics of the wire and the manner of making it up vary within wide limits in accordance

FIG. 1. MANILA FIBRE, BALED.

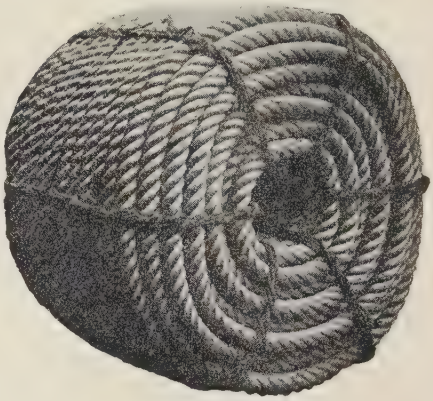


FIG. 2. ROPE IN COIL.

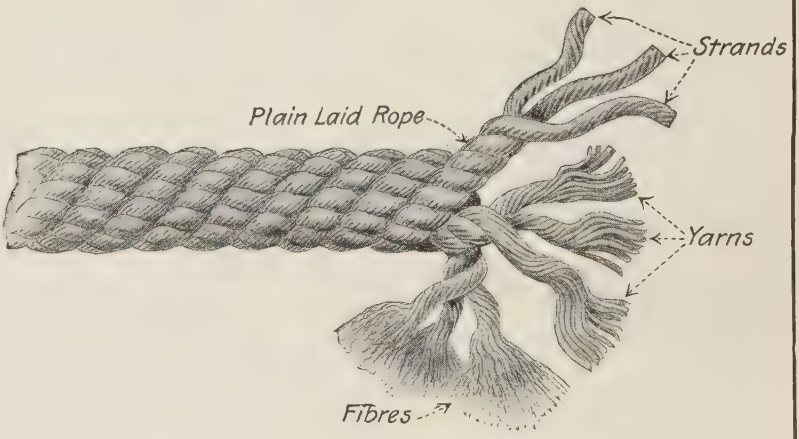


FIG. 3. CABLE LAID ROPE.

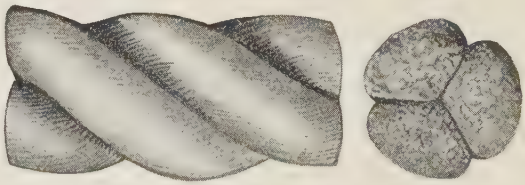
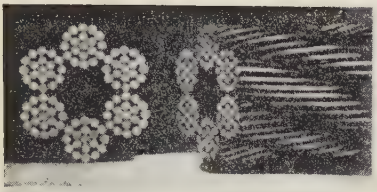
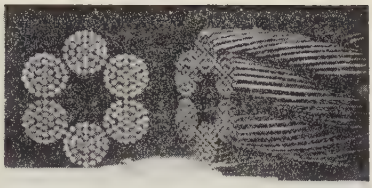


FIG. 4. CROSS SECTION, 3-STRAND ROPE.

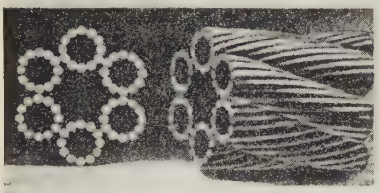
MANILA ROPE.



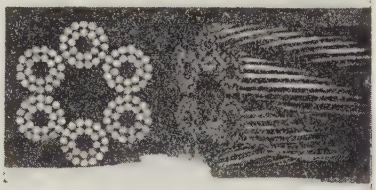
Strands of 19 Wires (6×19).



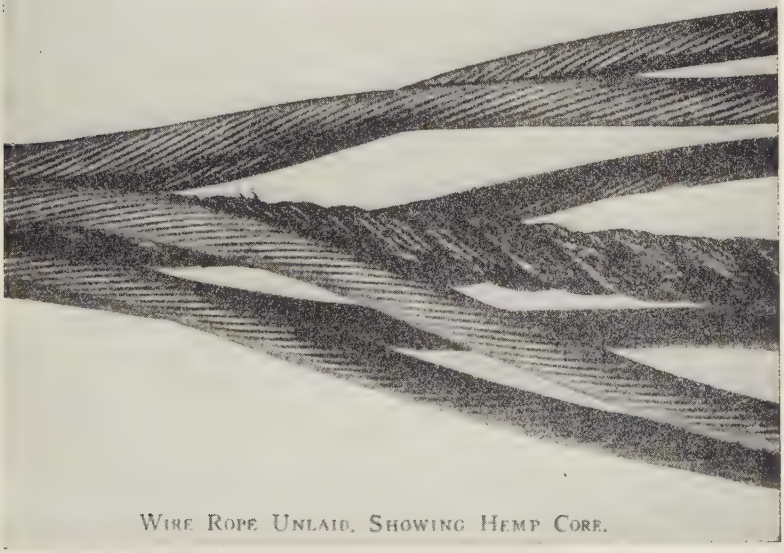
6 Strands of 37 Wires (6×37).



Strands of 12 Wires (6×12).



6 Strands of 24 Wires (6×24).



Wire Rope Unlaid, Showing Hemp Core.

TYPES OF WIRE ROPE.

with the purpose for which the rope is intended. Where great flexibility is wanted, as in the case of rope to be worked over sheaves, this quality is secured at some sacrifice of strength. Such rope should not be galvanized unless it is to be exposed to the weather or to extreme dampness. Where a steady stress is to be provided for, as in the case of standing rigging, the tensile strength is of maximum importance; and in this particular instance (standing rigging), galvanizing is essential because of the necessary exposure to weather. The number of strands will depend upon the purpose for which the rope is designed, as will also the nature of the core. As a rule, six strands are used, laid up around a hemp core. The number of wires to a strand varies widely but the two most commonly used types consist of 6 strands of 19 or 37 wires to the strand. In both of these types, known as the "6 × 19" and the "6 × 37" types, the strands have wire cores. Approximately 75 per cent of the wire rope used in the United States Naval Service is of the 6 × 37 type, this being considered to give the best all-around combination of qualities and the best balance of strength and flexibility. Where greater flexibility is required the 6 × 24 type should be selected, or, if strength is not important, the 6 × 12. Both the 6 × 24 and the 6 × 12 types have a hemp core for each strand as well as for the rope. (Plate No. **22**)

The strength of wire rope increases with the strength of the material from which it is made. The weight and the diameter of a wire rope for a particular purpose can be reduced by using a stronger material, as, for example, by using plow steel instead of cast steel; or by using a stronger material, the strength, and therefore the safe working load can be increased for a given weight and diameter. Naval specifications require the minimum tensile strength of the main units in a wire rope to be as follows:

Cast steel	155,000	lbs. per sq. inch if galvanized
	170,000	" " " " " uncoated
Extra-strong cast steel	170,000	lbs. per sq. inch if galvanized
	190,000	" " " " " uncoated
Plow steel	190,000	" " " " " galvanized
	210,000	" " " " " uncoated
High-grade plow steel	210,000	" " " " " galvanized
	230,000	" " " " " uncoated
Phosphor bronze	90,000	" " " " " uncoated

The Manufacture of Wire Rope.

Wire ropes are made almost exclusively from steel. The first requisite in the manufacture of steel wire is the selection and blending of the different iron ores which determine the chemical composition of the steel ingots. After selecting the proper steel (iron, cast steel, extra strong cast steel, plow steel or high-grade plow steel) from the open hearth furnace, the large ingots are reheated and rolled to billets about 4 by 4 inches, cut in small lengths, again reheated and rolled to small bars, and again into small rods of one-fourth inch to one-half inch in diameter. Next, the wire is drawn, cold, through dies, to the desired size. The action of drawing has the effect of hardening the wire and making it brittle, so that annealing must be done at intervals to soften it again for further drawing. During wire drawing, various lubricants such as oil, tallow and soapy water are employed to facilitate the operation.

The fundamental unit in wire rope construction is the strand. Strands are formed by winding individual wires in a spiral direction around a core. This is done by a stranding machine. A vast number of geometrical combinations of wires is possible, but for ordinary work, the practice is to use one wire in the center of the strand, surrounding this with a layer of 6 wires, then successively with layers of 12 and 18 wires. The addition of one layer of six wires around a center will produce a strand for a haulage rope. A supplementary layer of 12 wires makes a 19 wire strand for a hoisting rope, etc.

The finished strands are wound upon large bobbins and twisted into rope by means of a rope-closing machine. The standard wire rope is made of six wire strands and a hemp core. This arrangement affords the most convenient and compact form as the strands and the core are practically all of the same size.

The use of hemp for the center of the rope not only contributes to flexibility, but has the further advantage that the hemp forms a cushion upon which the strands close in as the rope contracts under heavy pull, thus acting with the elasticity of the wire and the "give" which results from the spiral lay, to reduce the effect of sudden stresses. When the hemp center has absorbed its share of the lubricant which should be used upon the rope from time

to time, this cushioning will result in a lubrication of the interior wires and greatly reduce the interior friction.

Galvanizing is the simplest and most efficient means known for preserving wire from corrosion, but it involves exposing the wire to a temperature of 800°—850° Fahrenheit, which reduces the strength approximately 10 per cent. The process of galvanizing consists of drawing the wire slowly through a bath of molten zinc, from which it takes on a thin but very tenacious coating, sufficient to protect it from the corrosive action of moisture. Such protection is especially important for wire which is to be exposed to salt water.

Each wire is subjected to bending and torsional tests, and tests for elongation and tensile and elastic strength. It is also carefully examined, visually, foot by foot, to make sure that it is free from surface defects. It is the fact that these tests can be made, and are made, upon every individual wire entering into the finished rope, which gives to wire rope its most valuable characteristic, *reliability*.

Characteristics and Uses of Various Types of Wire Ropes.

In choosing a wire rope, the selection of type of construction is practically independent of the loads involved. The type of construction does depend upon whether the rope is to remain stationary or is to operate over sheaves, fair leads, drums, etc., and if of the latter class, the speed at which it will run, the size of such sheaves, and the material of which they are made. Plate No. **22** shows various types of wire rope suitable for different purposes.

6 × 19 type is the stiffest and strongest type manufactured for use on shipboard. Ungalvanized, it is particularly useful on derricks and dredges. It may be used over sheaves of large diameter where the speed is moderate, but has not the flexibility required for running rigging in general. Galvanized, this type may be used for standing rigging, guys, boat slings and topping lifts. Phosphor bronze wire rope of 6 × 19 construction may be used for life lines, wheel ropes or rigging, where either non-corrosive or non magnetic properties are desired.

6 × 37 type, ungalvanized steel wire rope of 6 × 37 construction is a very flexible rope, suitable for cranes and similar machinery where sheaves are of necessity smaller than desirable. It is a very efficient rope, because a little over 50 per cent of the wires, and consequently over 50 per cent of the strength, are in the inner layers of the strand, protected from abrasion.

On naval vessels it is used customarily for crane falls, steering gear ropes, and in general for running ropes which pass around sheaves, under such conditions that they can be kept slushed with graphite or other preservative lubricant. Galvanized, this type may be used for steering gear ropes, boat crane falls, towing hawsers, bridles, relieving tackles, tiller ropes, clear hawse pendants, dip ropes, torpedo slings, slings for general hoisting, hawsers where great strength is required and heavy running rigging.

6 × 12 type. This type is more flexible than the **6 × 19** or **6 × 37** wire but is not as strong as these. It may be used for life lines, guys, ridge ropes, boat ladders, Jacob's ladders, boom pendants and mooring lines. Galvanized, it is sometimes used for running rigging where extreme flexibility is required and exposure to moisture frequent.

6 × 24 type. Galvanized wire rope of this type has almost the same flexibility as the **6 × 12** type but is stronger. It is used primarily in the larger sizes, where the strength of a **6 × 12** rope of same size will not be satisfactory and where extreme flexibility is the major consideration.

Stresses on Wire Rope. The load stress may be, but seldom is, the total stress on a wire-rope installation. Other stresses which may be present are: (*a*) stress due to bending rope over a sheave or drum, commonly known as bending stress; (*b*) stress due to change of velocity of load, *i.e.*, dynamic stress; (*c*) stress due to friction; (*d*) stress due to the weight of the rope itself.

In Naval installations, the load stress is frequently half or less than half of the total stress. Calculations of the size of wire rope required in a given design based only on the load stress are therefore likely to be very misleading. The computations of the load stress may be simple or involved. In any case both this and all other stresses to which the wire is subjected should be carefully calculated, so that the total stress may be accurately known and the proper rope selected with confidence.

The bending stress varies inversely as the diameter of the sheave on which it is used. It may be found from the following formula:

$$S = E \frac{d}{D} A$$

where S = total bending stress in rope
E = modulus of elasticity for wire rope
d = diameter outside wires in rope
D = diameter of sheave
A = aggregate area of wires in rope.

The stress set up in a wire rope by reason of change of velocity of load is known as the dynamic stress. Such stress may be produced by starting a load from rest at high speed, sharply accelerating a slowly moving load, or by suddenly slowing down or stopping altogether a load being lowered by its own weight. The formula for computing such stress is:

$$F = w\frac{a}{g}$$

In which F = dynamic stress
w = load
g = acceleration of gravity = 32.2
a = acceleration or deceleration applied to load.

Due to the manifest difficulty of making an accurate determination of the acceleration, the dynamic stress for boat falls is generally regarded as 10 per cent of the load stress.

In Naval installations, except spans, the weight of the rope itself is practically always negligible.

Factor of Safety for Wire Rope. In addition to being suitable for a particular service by its type of construction, a wire rope must be strong enough to stand the stresses put upon it without permanent deformation or hazard to life and property and to give a reasonable amount of service; *i.e.*, not require frequent renewal. The strength of a wire rope of a given construction depends upon the diameter and the material from which made. The breaking strength for any given rope may be found from the tables in the Appendix, and a new rope can be depended upon not to part at a load less than the tabular value. A suitable margin of safety between the total load and the breaking strength of a new rope must be allowed. The proper size of wire rope for a given installation should be determined after calculation of the total stress in the rope from all causes and the use of a factor of safety suitable to the conditions of service and seriousness of failure. In general, the following factors of safety may be used· A factor of safety of 3 is the minimum for working conditions. For ordinary hoisting ropes on shipboard a factor of 3½ is considered suitable. Where deterioration may be expected due to such causes as unusual abrasion, high speed, and

poor lubrication, a higher factor of safety should be provided. A factor of safety of 5 should be used in cases where the rope is subjected to more or less continuous use and to considerable wear and where failure would involve high risk of injury to personnel.

Care of Fibre Rope. Unlike metal, fibre has not a permanent elastic limit within which it can be worked indefinitely. Therefore, no attempt should be made to put a maximum strain on a rope which has seen continuous service under a moderate strain nor on one which has once been close to the breaking point. The safety of a rope decreases comparatively rapidly with use, dependent to some extent upon the amount of strain. This is due to the fact that the fibres slip a small amount under each strain in spite of the twisting.

Rope tends to contract when wet, and unless allowed to do so freely may be injuriously strained. It is for this reason that running gear is slacked in damp weather. On the other hand, advantage may be taken of this tendency for tautening lashings, etc., by wetting the rope.

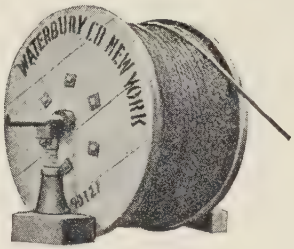
As rope deteriorates rapidly from continued dampness, it should never be stowed away unless perfectly dry. This caution is especially important in the case of hawsers, which are rarely used without being wet. It is a reason also for the rule that fibre rope should not be covered except when absolutely necessary, as covering not only holds the moisture but prevents the deterioration from being seen. If possible, rope should be stowed coiled on wooden gratings to allow for ventilation.

If a rope develops kinks or turns it may be due to its being always taken around the capstan or drum of a winch in one direction. Putting the turns on the opposite way will usually rectify this.

Care of Wire Rope. Wire rope needs in some ways better care than hemp or manila and far better care than it generally receives on shipboard. It should be kept on a reel when not in use. A single kink in the finest wire rope practically ruins it at once.

In receiving a line and transferring it from one reel to another, care should be taken to unreel it, instead of slipping off the successive bights over the end of the reel, as is sometimes done.

Plate **23** illustrates the right way and the wrong way of dealing with wire rope under various conditions.



Right Way.

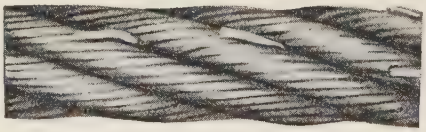
Wrong Way.

To Take Rope From Reel.

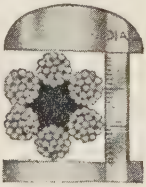
Right Way.

Wrong Way.

To Take Rope From Coil.



An Overworked Rope.

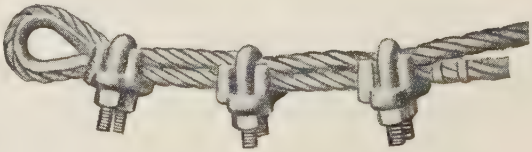


Right Way.

Wrong Way.

To Measure Diameter.

Right Way (U-bolt on Dead End).



Wrong Way (U-bolt on Tension End).

Wire Rope Clips,

A wire hawser should be gone over thoroughly every month or two with linseed oil; or better, if it is not to be used for some time, with crude petroleum or some heavy lubricating oil to which a small quantity of graphite has been added. If the lubricant used is inclined to be stiff, it is better used hot. Neither oils nor tars can be regarded as perfect preservatives, as they all contain more or less acid, which attacks the steel. The principal reliance must therefore be upon the galvanizing. If the rope is to remain under water for some time, the best preservative is made by adding to one part of Stockholm tar, one part fresh slaked lime. Boil well and use while hot for saturating the rope.

It is important that the lubricant, whatever its composition, should be thin enough to penetrate into interstices of the rope and yet that it should have consistency enough to adhere to the wire for a reasonable length of time, after which it should be renewed. Care must be taken to insure covering the rope all around. A hawser used for towing should be relubricated after use while being reeled up.

Wherever wire rope is to be worked over a sheave, the diameter of the sheave and the speed of running become very important factors.

The larger the sheave and the lower the speed, the better. All manufacturers of wire rope prescribe a minimum diameter for sheaves, and their guaranteed breaking strains and estimated safe-working loads are for these minimum diameters, and for moderate speed. A high speed increases the wear upon the rope, not only by the friction on the sheaves but still more by the friction of the wires upon each other—a point which is often overlooked.

The importance of this interior friction will be realized if we consider the "play" which necessarily goes on between the fibres of a rope which is being alternately bent and straightened in running over a sheave. This play, of course increases with the speed and is greater with a small sheave than with a large one. The same consideration enters in where a rope is alternately stretched and relaxed under a straight but varying pull; as, for example, in towing.

The diameter of the sheave over which the rope is worked should never be less than twenty times that of the rope itself; and the less flexible the rope the larger should be the sheave.

It is important that the score of the sheave should be of such size as to carry the rope without excessive play, and above all, without friction against the sides of the score. Metal sheaves are not required to be lined with wood or leather.

The turns of the rope should never be allowed to overlap on the drum of the winch.

As the wear of the rope over a sheave increases more rapidly with the speed than with the load, it is better, when an increased output is demanded, to increase the load than to increase the speed.

In addition to the question of *friction* in running over a sheave, the distortion of the rope wherever it passes around a relatively sharp bend, whether on a moving sheave or a stationary chock or bollard, is a factor of great importance. Those fibres which lie farthest from the center of the curve are stretched, while those which hug the round of the bend are more or less compressed. Thus the outer fibres give way before the inner ones begin to feel the strain.

By far the most unfavorable conditions to which wire rope can be subjected are those in which it runs over sheaves which give it a reverse bend, like the letter S, such that it passes over one sheave with a bend to the right and immediately afterwards swings around another with a bend to the left.

While the strength, lightness and durability of wire rope are important factors in its favor, its most valuable characteristic, as compared with hemp, manila, and chain, is its reliability. Within proper working limits, it almost never fails. Hemp and manila may be rotten at the core and show no sign, or they may have been weakened by excessive strains and give no indication of it except, perhaps, that they are a little "long-jawed." A chain may be made of worthless material, or, if of the best material and made with every care, it may have flaws which no inspection can reveal.

Hemp and manila ropes are made up of a great number of fibres from a few inches to several feet in length. Wire rope is made of small numbers of wires of the full length of the rope, each of which is manufactured, inspected, and tested, *individually,* throughout its full length before it goes into the rope. The inspection is so simple that a flaw can hardly be overlooked and it is most improbable that any number of wires can have flaws

which in the end appear at the same point of a strand. Thus it is almost impossible that any serious flaw should exist in a wire rope as manufactured.

A flaw due to kinking can always be seen.

An accident with wire rope is almost necessarily due to carelessness.

Assuming the rope to have a well-lubricated hemp core, and to be used over properly proportioned sheaves, the outside strands will be the first to wear out, and the reduction in their diameter becomes the measure of the wear of the rope as a whole.

Wire rope should be condemned when the outside wires are worn down to one-half their original diameter, or when it is apparent from broken wires or other abnormal indications that it has been subjected to danger by excessive strains, or to a sharp bend resulting in a pronounced kink.

When wire rope is to be cut, a whipping of small soft (annealed) iron wire should be wrapped on each side of the point where the cut is to be made, to prevent the rope from unlaying. If suitable annealed wire is not available, a fairly heavy *seizing stuff* may be used, the turns being passed very taut.

Standing rigging is protected from the weather by a coating of Stockholm tar mixed with tar and oil and alcohol. If Stockholm tar is not available a mixture of pine tar, alcohol and coal tar should be used. Wire rope exposed to the weather (such as mooring lines) is protected by a coating of raw linseed oil or with a paint compound of lamp black and linseed oil. Wire rope to be used under water is coated with a mixture of mineral tar and fresh slacked lime. The mixture is boiled and the rope is saturated with it while hot.

CHAPTER IV.

KNOTTING AND SPLICING.

The art of working in rope can only be learned from practical experience, but the illustrations and explanations which accompany this Chapter will give an idea of the most common knots, hitches, bends, splices, etc., in general use and should be helpful up to a certain point in making them.

WORKING IN HEMP AND MANILA.

KNOTS—PLATE 24.

This plate shows a number of simple knots, all of which are made with the end of a single rope.

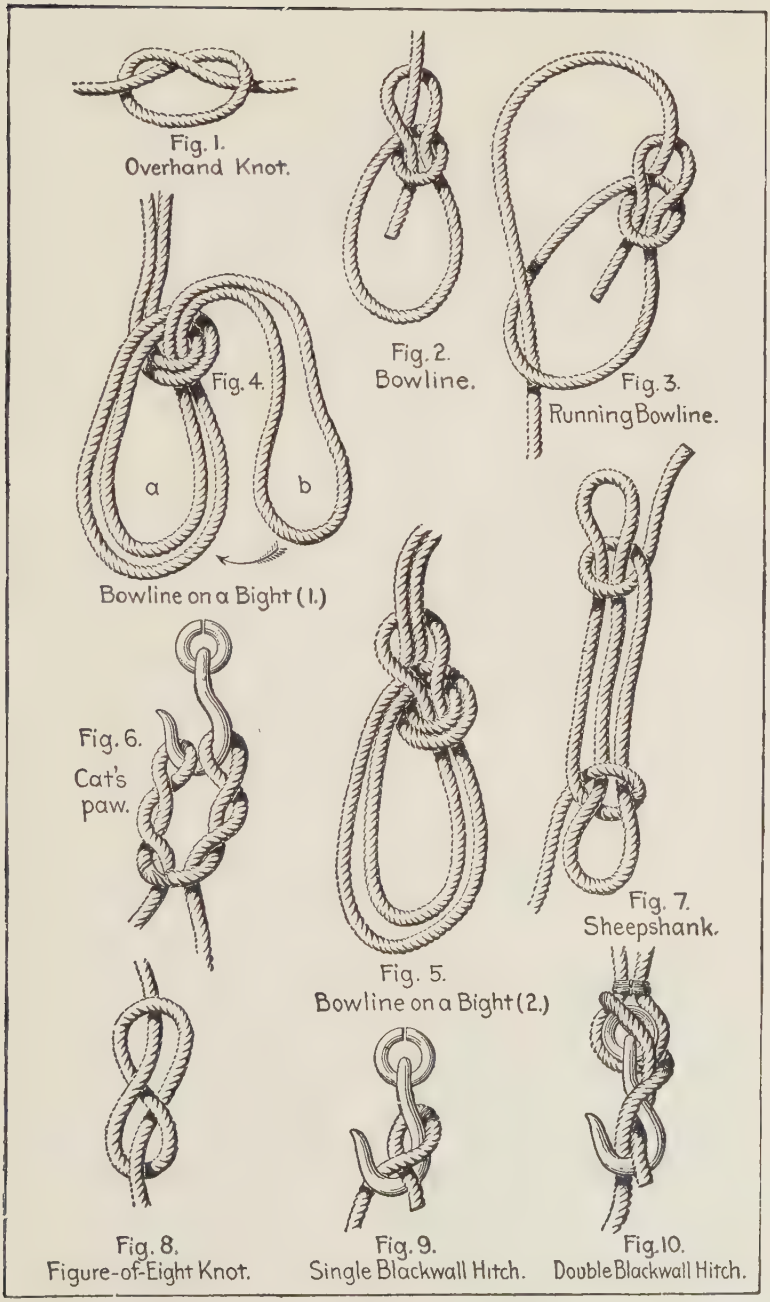
Overhand Knot, Fig. 1. A simple knot formed by passing the end of a rope over the standing part and through the bight.

Bowline, Fig. 2. One of the most common and useful knots. It forms a loop, which may be of any length and which cannot slip. It is used for lowering men over the side, to form a loop in the end of a hawser to be thrown over a bollard in handling a ship alongside of a dock, and for a great variety of similar purposes. Place the end part on the standing part and form a loop with the end through; pass the end under the standing part and bring it back through the loop.

Running Bowline, Fig. 3. A convenient form of running loop. Used when a running loop is needed. Formed by making a bowline over its own standing part.

Bowline on a Bight, Figs. 4 and 5. The bowline made with the bight of a rope. Dip the open single bight (*b*) over both double bights (*a*) and up above the loop and haul taut. Used where a greater strength than given by a single bowline is necessary, or when the end of the rope is not accessible.

Cat's Paw, Fig. 6. A double loop formed by twisting two bights of a rope. The hook of a tackle is passed through them. Convenient and secure.



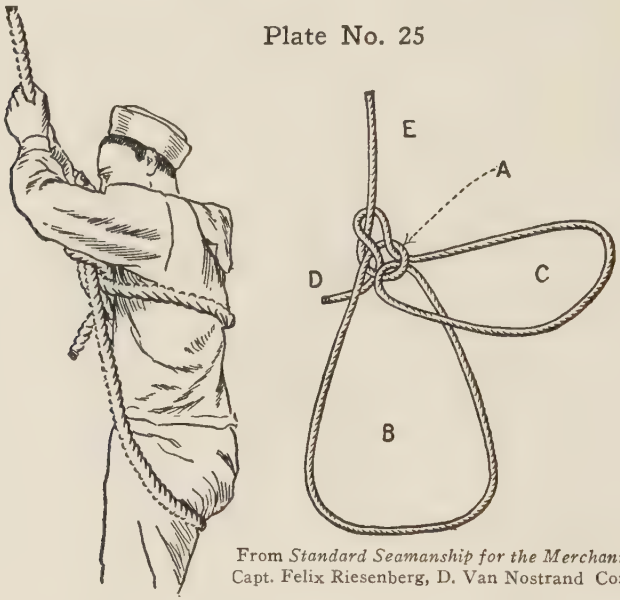
KNOTS IN THE END OF A ROPE.

Sheep Shank, Fig. 7. Used to shorten a rope. Lay the bight of the rope in three parts, and half hitch each part around the bight of the other two parts.

Figure of Eight, Fig. 8. A hitch resembling the figure eight and used to prevent the end of the rope from unreeving when rove through blocks. Pass the end of the rope round the standing part, under its own part and through the bight.

Blackwall Hitch, Figs. 9 and 10. A hitch either single or double around the back of a hook, the end on one side of the hook and the standing part on top, on the other side of the hook.

Plate No. 25



From *Standard Seamanship for the Merchant Service* by Capt. Felix Riesenberg, D. Van Nostrand Company, Inc.

"French Bowline." (Plate **25**). When sending a man over the side on hazardous work, into a smoke-filled hold, or anywhere where he may have to use both hands, make use of the French bowline. The bowline is formed in the same fashion as the regular bowline, except that the end (*D*), instead of going about the standing part (*E*) at once, is given a round turn about the bight of the eye (*A*), and then the knot is finished off as before. This leaves two loops that are loosely connected through the goose neck. The loops are made so that a man can sit in one—(*b*) while the other—(*c*) goes under his arm pits, the knot

being at his breast. The weight of the man hauls the arm pit loop taut, he is safe against falling out and is held upright if unconscious.

BENDS—PLATE 26.

This plate shows a series of knots for joining the ends of the two ropes or the two ends of the same rope. This is perhaps the most important group of knots with which we have to deal.

Square or Reef Knot, Fig. 1. A most important knot, and used for a great variety of purposes. Formed from an overhand knot by crossing the ends and bringing one end up through the bight alongside its own part.

Granny Knot, Fig. 2. Frequently confused with the square knot. Unseamanlike knot made instead of a square knot by a green hand.

Sheet or Becket Bend, Fig. 3. Used in bending on flags not fitted with snap hooks and very efficient for the purpose of uniting two ends of a rope or a rope's end to an eye. Made by passing the end of a rope up through the bight (eye) of another, round both parts and under its own part.

Sheet Bend, double, Fig. 4. Here the end of the bending line is passed twice around the standing line and through its own part, giving added security.

Single Carrick Bend, Figs. 5 and 6. A knot made by first crossing the end of one rope and then passing the end of the other down through the bight, under the standing part, over the end and down through the bight again. Used for joining two hawsers together.

Double Carrick Bend, Figs. 7, 8 and 9. More secure than the single Carrick (both ends coming out on different sides). With both, it is well to seize the ends to their own parts.

Two Bowlines, Fig. 10. A safe and convenient way of bending two hawsers together. Will not slip. Is somewhat bulky for use where the lines are to be veered out through a chock.

Reeving Line Bend, Fig. 11. A method of connecting two hawsers in such a way that they will reeve through an opening, offering as little obstruction as possible. Made by taking a half hitch with each end around the other hawser and seizing the ends.

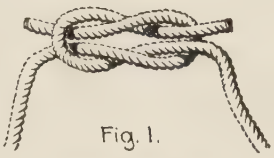


Fig. 1.
Square or Reef Knot.

Fig. 2.
Granny Knot.

Fig. 3.
Sheet or Becket Bend Single.

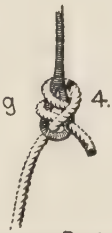


Fig 4.
Sheet or Becket Bend Double.

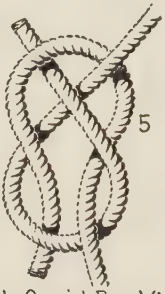


Fig. 5
Single Carrick Bend (1.)

Fig. 6.
Single Carrick Bend (2.)

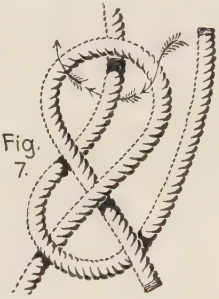


Fig. 7.
Double Carrick Bend (1.)

Fig 8
Double Carrick Bend (2.)

Fig. 9
Double Carrick Bend. (2nd Method)

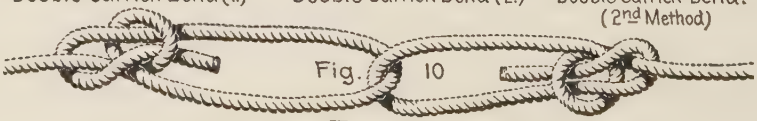


Fig. 10
Two Bowlines.

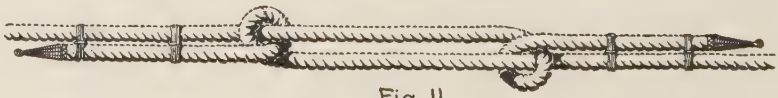


Fig. 11.
Reeving-Line Bend.

BENDING TWO ROPES TOGETHER.

BENDS—PLATE 27.

This plate shows various ways of securing lines to spars, posts, rings, etc.

Studding Sail Tack Bend, Fig. 1. A useful bend for a variety of purposes where it is important to have no danger of coming adrift through the flapping of a sail.

Studding Sail Halliard Bend, Fig. 2. The greater the pull on the halliards, the more tightly the parts of the bend are jammed against the spar. Formed by taking a round turn with the end coming around the standing part, under both turns and tucked over and under the turns.

Fisherman's Bend, Fig. 3. Used for securing a rope to a buoy, or a hawser to the ring or Jew's harp of an anchor. Formed by passing the end twice round the ring and under the turns. Seize the end back.

Timber Hitch, Fig. 4. Useful when towing spars. Formed by passing the end around the spar and its own standing part; then pass several turns around its own part.

Timber Hitch and Half Hitch, Fig. 5. The half hitch is taken first and the timber hitch afterwards formed with the end.

Rolling Hitch, Figs. 6 and 8. Very useful where one rope is to be bent to a spar or to the standing part (not the end) of another rope, or to a chain (as in clearing hawse). Pass the end twice round the spar or rope, crossing the standing part on the top side each time; then hitch the end round the spar or rope, on the opposite side of the two turns.

Round Turn and Two Half Hitches, Fig. 7. For making a hawser fast to a bollard, spar or another rope. Most useful and popular way to make a line fast.

Two Half Hitches, Fig. 9. Another method of bending a rope's end to a spar, a bollard or ring. Formed by leading the end over and under and up through the standing part and repeating the process.

Clove Hitch, Fig. 10. One of the most common hitches for attaching a rope to a spar or to the standing part of a rope. Pass the end around the spar, crossing the standing part, then around the spar again, bringing the end through between the end part and standing part under its own part.

Fig. 1.
Studding Sail Tack Bend.

Fig. 2.
Studding-Sail
Halliard Bend.

Fig. 3.
Fisherman's Bend.

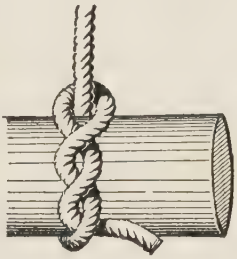


Fig. 4.
Timber Hitch.

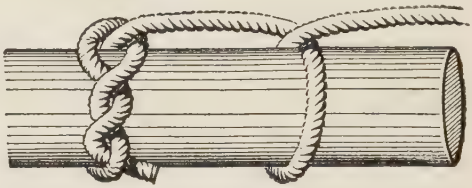


Fig. 5.
Timber and Half Hitch.

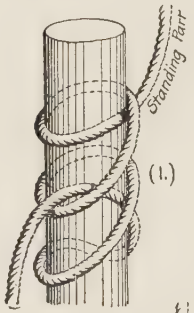


Fig. 6.

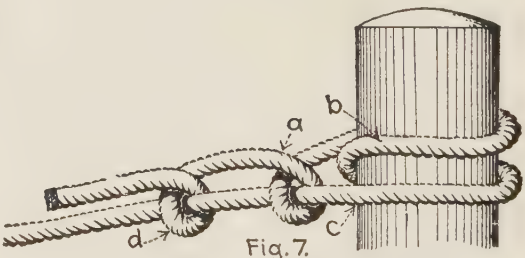


Fig. 7.
Round Turn and Two Half Hitches.

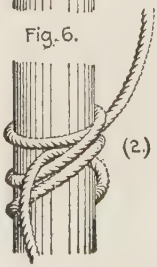


Fig. 8.
Rolling Hitch.

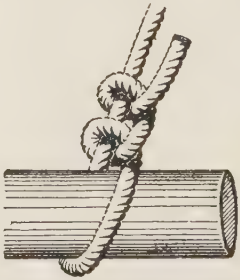


Fig. 9.
Two Half Hitches.

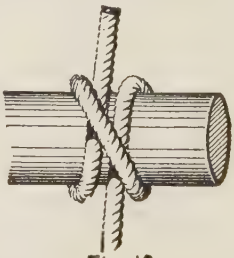


Fig. 10.
Clove Hitch.

BENDING A ROPE TO A POST, SPAR OR RING.

Stopper on a Rope. A short length of rope secured at one end, and used in securing or checking a running rope, e.g., deck stopper, boat fall stopper, etc.

Marline Hitch. Used in lashing hammocks, securing sails to spars.

PASSING A STRAP.

A strap (or strop) is often used to attach a block to rigging or to a rope; it being twisted around the rope to be hauled on and the block fitting is placed into the bight end(s).

FIRST METHOD. Plate 28, Fig. 1.

Take the loop of one end of strap and hold same on hawser; now pass other end of strap close around hawser until it is expended, allowing sufficient length to pass through loop first held on hawser.

SECOND METHOD. Plate 28, Fig. 2.

Take strap and hold center against hawser and pass both (crossing same) ends around hawser in opposite directions.

THIRD METHOD. Plate 28, Fig. 3.

Spread loop of one end of strap at right angles to hawser, now pass the other end of strap around hawser inside of loop until strap is expended.

SIGNAL HALLIARD SPLICE—PLATE 28.

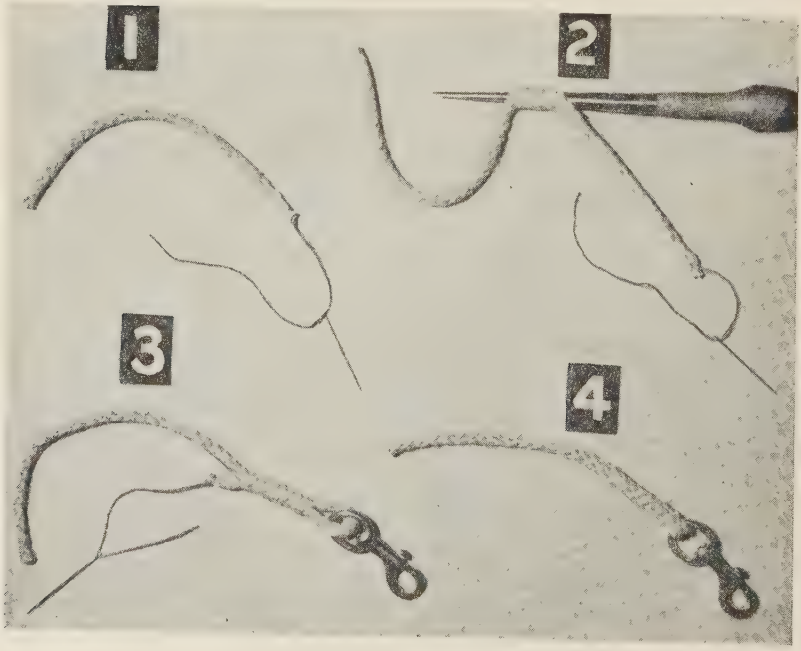
A Signal Halliard splice is an eye turned in the end of signal halliard for snap hooks and rings.

(1) About one inch or one and one-half inches from end of halliard cut out three (3) strands. Insert sail needle and twine through halliard about one and one-half inches from end and make marline hitch; make another marline hitch with needle and twine near end of halliard (this tapers end of halliard for tucking).

(2) Six inches from end of halliard insert a pricker down through center of halliard for about two inches.

(3) Haul sail needle, twine, and tapered end through halliard ring or snap hook to be used. Withdraw pricker and insert sail

THREE METHODS OF PASSING A STRAP.



SIGNAL HALLIARD SPLICE.

needle, twine, and tapered end through center of halliard. Cut off tapered end leaving about one-half inch of end.

(4) Haul out and smooth splice.

NOTE: For preservation, splice and fittings may be dipped in a solution of boiling bee's wax.

KNOTS WORKED IN THE END OF A ROPE—PLATE 29.

This plate shows a series of knots which are worked in the end or the body of the rope by unlaying the rope and using its own strands. A whipping is usually put on below the point where the knot is to be. Knots of this kind are sometimes used to give a finish to the end of the rope, sometimes to prevent unreeving, and sometimes merely for ornamental purposes.

Wall Knot, Fig. 1. Unlay the strands sufficiently to form the knot. Form a bight with strand 1 and pass strand 2 around the end of it, also strand 3 around the end of 2 and through the bight of 1, hauling the ends taut.

Wall and Crown, Fig. 2. Lay strand 1 over the center of the wall, strand 2 over 1, and strand 3 over 2 and under 1. Haul the strands taut and form the knot.

Double Wall and Single Crown, Fig. 3.

Double Wall and Double Crown or "Man-rope Knot," Fig. 4. The ends come out underneath and are hidden. Used at the end of a man-rope.

Matthew Walker Knot. Double and Single, Figs. 5 and 6, 7 and 8.

Whipping the End of a Rope. Figs. 10, 11 and 12. To prevent unlaying or fraying out. Lay the end of a length of stout twine along the rope and pass a number of turns around the rope and over the end of the whipping, hauling each turn taut. Fig 10. Then lay the other end of the whipping along the rope in the opposite direction from the first end, and pass a number of turns, on the bight, over this end. Fig. 11. Haul the end through and trim off.

Sailmaker's Whipping. Put on with a needle and twine. The rope is first struck through between two strands with the needle and the twine is drawn to the end. Several turns are passed around the rope and the rope struck through at each end of the whipping between the strands. Crossing turns are passed be-

Fig. 1.

Wall Knot.

Fig. 2.

Wall and Crown.

Fig. 3.

Double Wall and Single Crown.

Fig. 4

Double Wall and Double Crown or "Man Rope Knot."

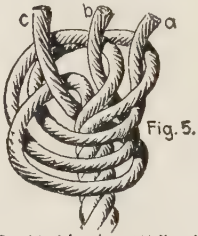


Fig. 5.

Double Matthew Walker (1.)

Fig. 6.

Double Matthew Walker (2.)

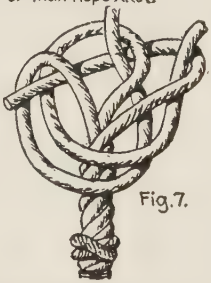
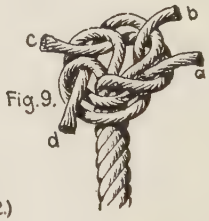


Fig. 7.

Single Matthew Walker (1.)

Fig. 8.

Single Matthew Walker (2.)



Laniard Knot (1.)

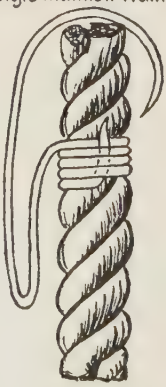


Fig. 10

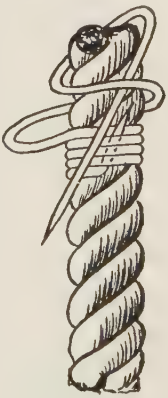


Fig. 11

Fig. 12

Whipping the End of a Rope

KNOTS WORKED IN THE END OF A ROPE.

tween strands and secured with two half hitches and hauled close down.

SPLICING—PLATE 30.

There are various forms of splices for joining the ends of two ropes permanently, or for bending the end of a rope upon itself to form a permanent eye. In making these, when the strands of a rope are to be tucked, the lay of the rope where they go through is opened out by means of a fid, and the strand tucked through once in its full size, then reduced in size by cutting away a certain number of threads, tucked a second time, reduced once more in size and tucked again. It is thus tucked once full size, once two-thirds, and once one-third. This produces a tapered and much neater splice than if it were tucked three times in full size.

Length of Splices. For eye splices and short splices whether in manila or wire, from 12 to 24 inches should be allowed for forming the splice, and for long splices ten times the circumference of the rope.

A Three Strand Eye Splice. The rope is unlaid for perhaps a foot from the end, and the strands brought back upon the body of the rope at a point which will form an eye of the size that is wanted.

Middle strand (a), up and a strand laying on either side, have eye towards you. Tuck as follows: (Fig. 2). Middle strand (a) under strand below it, left hand strand (b) over the strand under which the first strand was tucked and under the next (Fig. 3). Now turn the splice over (Fig. 4). Give the last strand (c) an extra twist with the lay and tuck it under the remaining strand. All strands are tucked from right to left. After first full tuck with the three strands, tuck each over and under twice more. If splice is to be finished and served, cut out a third of the yarns of the strand.

A Four Strand Eye Splice. Here the first strand (left strand) is tucked under two (but this is for the first tuck only); remaining strands each under one. All tucks from right to left.

A Short Splice, Figs. 5, 6 and 7. Two ropes are unlaid for a short distance and married together with strands interlacing (Fig. 5). The strands of each rope are then tucked through the

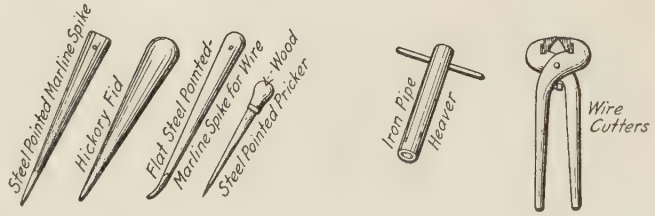


FIG. 1.
TOOLS FOR SPLICING

FIG. 2.
EYE SPLICE (1)

FIG. 3. EYE SPLICE (2)

FIG. 4.
EYE SPLICE (3)

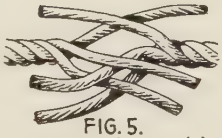


FIG. 5.
SHORT SPLICE (1)

FIG. 6.
SHORT SPLICE (2)

FIG. 7.
SHORT SPLICE (3)

FIG. 8. LONG SPLICE (1)

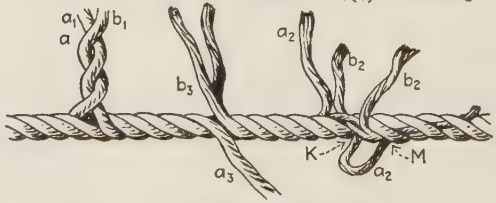


FIG. 9. LONG SPLICE (2)

lay of the other rope exactly as has been described in the case of an eye splice.

A Long Splice, Figs. 8 and 9. Here the ropes are unlaid for a greater distance than for a short splice and the ends brought together as before, with strands interlacing. Instead now of tucking at once, we proceed as follows: Unlay a_1, one of the strands of A, for a considerable distance, and in place of it lay up b_1, the adjoining strand of B, thus working a strand of B into A, for, say, a foot and a half to two feet. For convenience now twist up a_1 and b_1 together temporarily, as in Fig. 9. Turn the rope end for end, unlay b_2, one of the strands of B, and in place of it lay up a_2, the adjoining strand of A. a_3 and b_3 are left lying beside each without being unlaid. We now have three pairs of strands at different points of the rope. Beginning with a_2 and b_2 (for example) separate each of the strands into two parts, and taking one-half of each strand, overhand knot these together (K, Fig. 9) and tuck them as in a short splice, over one and under one of the full remaining strands in the rope (M, Fig. 9). The other pairs of strands (a_1, b_1) (a_2, b_2) are similarly reduced, knotted, and tucked. The spare half of each strand is trimmed off smooth, as are the ends of the other halves after they have been tucked.

WORKING IN WIRE-ROPE.

As already stated, wire-rope is usually six-stranded, with a hemp center. In splicing, we may work with the strands separately or in pairs. The work calls for special appliances and for a degree of skill such as can be acquired only by long practice under expert instruction. Something may be learned from careful description and much more from an occasional visit to a rigging loft; but the facilities which are available on shipboard do not admit of doing such work as is possible with a rigger's bench, a turning-in machine, etc. Where a heavy rope is to be bent around a thimble or the parts otherwise brought together for splicing or seizing, a rigger's-screw is needed. In the absence of this, a vise may be used, but less conveniently.

In tucking the strands of a splice, the lay of the rope is opened out and the *spike left in*, holding the strands apart until the tuck has been made. For hauling the strands through, a jigger is

used on each one, the body of the rope being held by another jigger or a lashing. After a tuck, the parts of the ropes are hammered down tightly upon each other. Wire-cutters are used for cutting off ends.

PLATE **31. A Long Splice in Wire.** Figs. 1 and 2. Put on a good seizing six to ten feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one to two feet from the end of the other rope. Unlay, open out the strands, cut out the center, and marry the ends together with strands interlacing. Cut the seizing on the short end. Unlay one of the short strands, following it up in the same lay with the opposite long strand, leaving end enough to tuck. Continue in the same manner with the remaining strands, except as to the distance to which they are laid up, this distance being varied in such a way as to leave the successive pairs an equal distance apart, as shown in Fig. 2. Commencing with any two strands, half knot them together (full size), then divide each into three parts and tuck these parts separately as shown; or, cut out a few inches of the center and insert the ends of the strands in its place in the center of the rope. When a splice is to be served, the latter way of finishing it off answers very well.

Second Method (Figs. 3 and 4). Will be clear from Plate.

PLATE **32. A Short Splice in Wire.** Fig. 1. Put on a good seizing two or three feet, according to the size of the rope, from the end of the ropes to be spliced, and a similar seizing one or two feet from the end of the other rope. Unlay the ends and open out the strands, cutting out the heart close to the seizings. Marry them together and clap on a temporary seizing around the short ends and the body of the rope, to hold the parts close together. Commencing with any one of the long strands, tuck each in succession over one and under two strands, opening out the lay with a spike. Tuck the remaining strands in the same manner; twice whole strands, once one-half, and once one-quarter, hauling through with a jigger each time. Then turn the splice around, cutting the temporary seizing on the short ends, and tuck the short strands once one-half and once one-quarter, heaving them through with a jigger. Hammer down all parts and trim off the ends.

An Eye Splice in Wire. Fig. 2. Get the rope on a stretch, allow from 18 to 24 inches from the end for splicing, and put

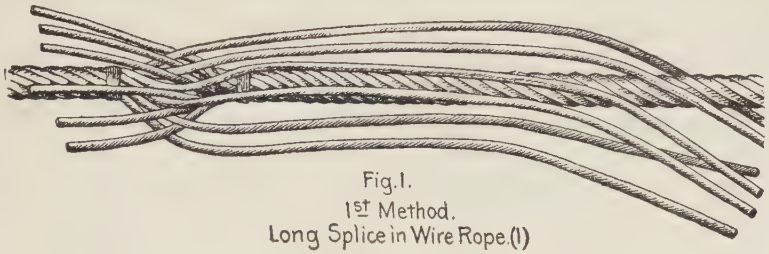


Fig.1.
1st Method.
Long Splice in Wire Rope.(1)

Fig. 2.
1st Method.
Long Splice in Wire Rope.(2)

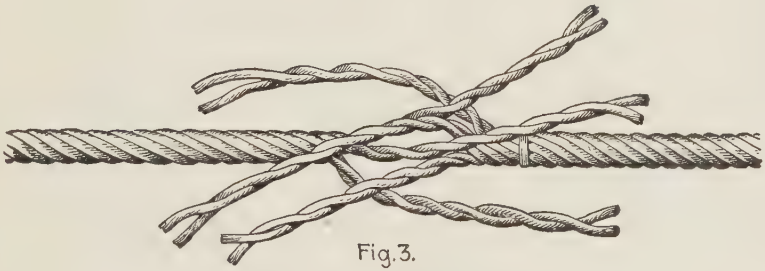


Fig.3.
2d Method.
Long Splice in Wire.

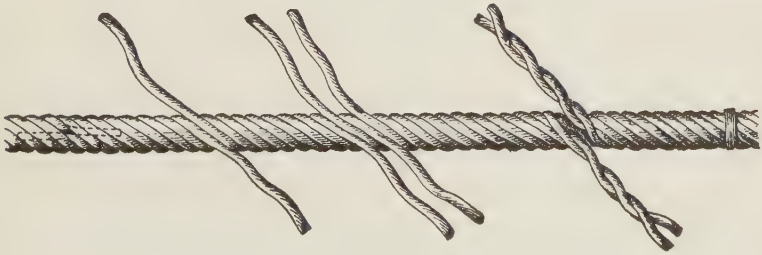


Fig.4.
2d Method.
Long Splice in Wire.

LONG SPLICE IN WIRE.

on a mark with a couple of turns of twine. Measure along the rope from this mark the length of the eye (one and one-half the round of the thimble) and put on another similar mark. Paint with red lead, worm, parcel, paint again, and double-serve between the marks. Now come up the stretch and seize the thimble in, breaking the wire into the shape of the thimble, heaving both parts together with a rigging screw and putting a good racking seizing around both parts. Come up the screw, unlay the end of the wire, and cut out the heart close to the service. Now, with the thimble toward you, counting from right to left 1, 2, 3, etc., stick No. 4 strand from right to left under the two upper strands of the rope just clear of the service, opening the strands by a spike. Haul through by hand. In the same manner —under two strands—tuck the remaining strands, in the following order: 3, 5, 2, 6, 1. Now, commencing with any strand, tuck again whole over one and under one and haul through by means of a jigger. Hammer the strands down in place, cut each strand down to two-thirds size and tuck again, hauling through with a jigger as before. Cut the strands down to one-third and tuck again. Hammer down all strands and cut off the wire with a wire-cutter.

WIRE ROPE GROMMETS.

A popular method of laying up a grommet of wire is to use two strands, carefully unlaying them from the rope and keeping them in their normal position in relation to one another. The length of the two strands used is something more than three times the circumference of the grommet to be made. Form the grommet of the bight of a left-handed overhand knot. Lay each double end around in the lay of the bight until they meet. This will bring four ends together, with a pair pointing each way, and six strands around the bight or grommet. Now cast off the seizing that holds the ends of pair of strands together. Unlay one strand's end in the lay vacated as the strand was unlaid. This will separate the points at which pairs of opposing ends meet. Having separated the meeting points of opposing parts, cross and tuck the ends in the same manner as in tucking the ends for a long splice.

Plate **32,** Figs. 3, 4, 5, 6, 7, 8. Seizings for binding two ropes or two parts of the same rope. The manner of passing them is

Fig.1
A Short Splice in Wire

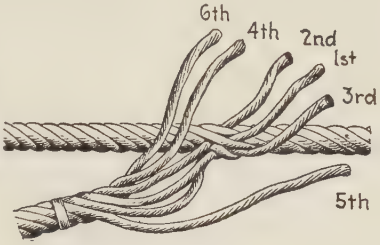


Fig.2
An Eye-Splice in Wire

Fig.3
Round Seizing

Fig.4
Round Seizing

Fig.5
Round Seizing Crossed
Clove Hitch Finish

Fig.6
Racking Seizing

Fig. 7
Racking Seizing

Fig.8
Throat Seizing

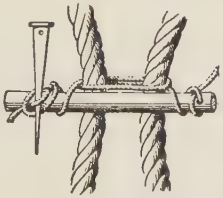


Fig.9 Spanish Windlass

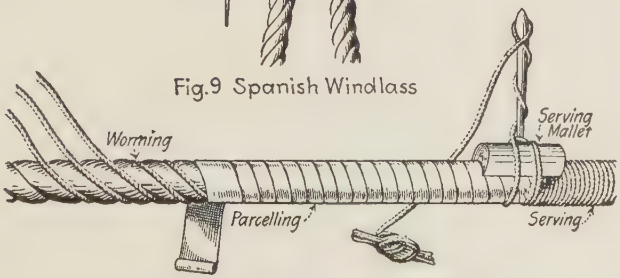


Fig.10 Worming, Parcelling and Serving

made clear by the figures. With heavy ropes, the parts must be hove together by power of some kind, such as a Spanish Windlass, a rigger's-screw, or a turning-in machine.

Worming, Parcelling, and Serving. Fig. 10. Rope which is to be exposed to the weather or to exceptionally hard usage is protected by worming, parcelling, and serving.

Worming consists in following the "lay" of the rope, between the strands, with small-stuff, tarred, which keeps moisture from penetrating to the interior of the rope, and at the same time fills out the round of the rope, giving a smooth surface for the parcelling and serving.

Parcelling consists in wrapping the rope spirally with long strips of canvas, following the lay of the rope, and overlapping like shingles on a roof to shed moisture.

Serving consists in wrapping small-stuff snugly over the parcelling and is done against the lay of the rope. A "serving mallet" is used for passing the turns, each turn being hove taut by the leverage of the handle so that the whole forms a stiff protecting cover for the rope.

A **Spanish Windlass**, for drawing two taut ropes together. Fig. 9.

Appliances for Use with Wire Rope. Plate **33.** Most of the appliances for use with wire rope are designed to provide some sort of an eye on the end of the rope, by which it can be connected with another rope or with a tackle, or otherwise secured. Plate **33** illustrates a number of these. It will be seen that any two of the ends shown can be joined together, either directly or by the aid of a shackle. Fig. 2 shows a handy *clip* and the manner of applying it. These clips, when made of drop-forged steel and properly applied, are little if at all inferior to a splice, and they can be applied in a few moments where a splice would take as many hours. In the emergencies which sometimes arise on shipboard, as in handling anchors, taking a vessel in tow, etc., when an eye is needed in a hawser and there is not time to make a splice, these clips would be invaluable. They can be removed as quickly as they are applied, breaking down the eye at once.

A set of these in sizes to fit any hawser on board might well be issued to all ships. Note that the U-bolt is always applied to the "dead" end of the rope.

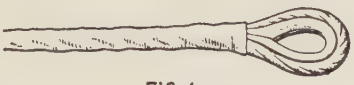


FIG. 1
THIMBLE EYE, SPLICED AND SERVED

FIG. 2
THIMBLE EYE WITH WIRE ROPE CLIPS

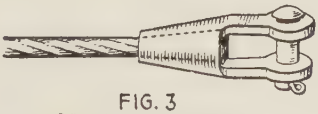


FIG. 3
OPEN END SOCKET

FIG. 4
CLOSED END SOCKET

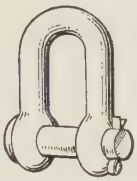


FIG. 5
SHACKLE

FIG. 6
HOOK AND THIMBLE

FIG. 7
TURNBUCKLE

FIG. 8
JOINING THE ENDS OF ROPE

APPLIANCES FOR USE WITH WIRE ROPE.

The *socket* shown in Figs. 3 and 4 is the strongest attachment known for use on the end of a wire rope. The interior of the base of the socket is coned and the bare end of the rope is bedded in and sealed with molten zinc, which forms a head that holds without distortion of the wires.

CHAPTER V.

MECHANICAL APPLIANCES ON BOARD SHIP.

Tasks requiring the use of booms and topping lifts, shear legs, spans, and tackles are the daily lot of seamen. Blocks and falls for rigging the many different purchases are necessary for handling weights after the booms and shear legs have been rigged. In addition to these, there are patent chain hoists operating on different mechanical principles available for use on board ship. The object of this chapter will be to point out basic principles necessary to solve for forces of compression and tension that exist in the several members of ordinary devices used in handling weights on board ship.

Before going into the discussion of principles involved, a summary of the mechanical principles is reviewed:

1. A Force is defined when its magnitude and line of action are known.

A Force can be represented by a vector.

2. If a point (body) is in equilibrium under the action of three forces those forces form a force triangle. Or, any one of the forces is equal and opposite to the resultant force of the other two.

3. The resultant of two forces can be found from the parallelogram of forces.

4. Forces can be resolved horizontally and vertically.

5. If a body is in equilibrium under the action of a system of coplanar forces, then the sum of the moments about any point in their plane must be equal to zero and the sum of the components of the forces in each of two perpendicular directions must be equal to zero.

It is conventional to indicate forces of tension by arrow heads pointing away from the joint of structure members; forces of compression by arrow heads pointing toward the joint.

In drawing the force diagrams and in the discussion of them the weight is considered to be suspended and not moving. Fur-

ther, no consideration has been given to the forces acting in the hauling parts of the various purchases.

Booms and Topping Lifts.

Plate **34,** Figure 1, shows a simple boom and topping lift supporting the weight *W*. Call the point where the center line of the topping lift intersects the center line of the vertical mast *A*. The point of intersection of the center lines of the boom and mast *B*, and the point of intersection of the center lines of the boom and topping lift *C*. We wish to find the forces acting on the boom, topping lift, and stay; the thrust exerted by the heel of the mast on its step.

At *C* draw the line of action *Cm* of the force due to weight *W*. On *Cm* lay off to scale (one inch equal *W*) and locate *m*. From *m* draw a line parallel to the center line of the boom and from *C* extend the center line of the topping lift. The point of their intersection call *o*. On *Cm* draw an arrow pointing downward to indicate the direction of action of the force of the weight *W*. For the condition of equilibrium to obtain at *C* the forces must act to form a closed force diagram. Therefore the arrows must point head to tail around the triangle *Cmo*. The direction of the arrow on *mo* shows that the boom is under compression; the direction of the arrow on *Co* shows that the topping lift is in tension. By measurement *mo* equals one inch; *Co* is 1.2 inches. To scale the compression on the boom equals *W* and the tension on the topping lift equals 1.2 *W*. At point *A* the topping lift is pulling the mast. Represent this by placing an arrow pointing toward *C* on the mast end of the topping lift. The tension on the topping lift is 1.2 *W*; lay off this distance from *A* on the topping lift in the direction of *C* and locate point *s*. Through *s* draw a line parallel to the direction of the stay and where this line intersects the center line of the mast call *t*. Measure *st* to scale. Its measurement is 1.58 inches. This means that the tension on the stay is 1.58 *W*.

Note that the arrows on triangle *Ast* point head to tail and are based on the known direction of the tension in *AC*. The arrow on *tA* pointing toward *A* means that the mast is under a compressive stress at *A* of 1.98 *W*, caused by the downward pull of the tension in topping lift and stay.

On Figure 2 is shown the vertical and horizontal components of all forces acting at each point. At point A the horizontal components of the tension in guy and topping lift are equal and opposite. The vertical component of the tension on the stay is 1.27 W, that of the topping lift 0.71 W, therefore the mast pushes upward at A with a force 1.98 W.

At B the boom has a downward thrust of 0.25 W and a horizontal thrust of 0.96 W, therefore the sum of the vertical forces acting on the mast are 0.25 W at B, 1.98 W at A, so that the mast is pushing vertically downward on its step with a force 1.98 W plus 0.25 W or 2.23 W. Another force acting on the mast is the horizontal component of the boom thrust, 0.96 W, at B. The resultant of these forces is: the mast pushes downward on its step with a force of 2.45 W, in a direction 156 degrees to the left of the mast. At C the vertical thrust of the boom plus the vertical component of the tension on the topping lift are exactly equal and opposite to the weight W. The horizontal components of thrust and tension at C are equal and opposite. At D the stay is pulling on the deck, therefore the forces acting to resist these must be the equal and opposite to the horizontal and vertical components of the tension of the stay.

Referring again to Figure 1, Tringle Cmo is similar to Triangle ABC.

Hence the proportion:

$$\frac{Cm}{AB} = \frac{mo}{BC} = \frac{Co}{CA}$$

$$\text{or } \frac{\text{Weight}}{\text{length } AB} = \frac{\text{Compression in boom}}{\text{length of boom}}$$

Once the structure is rigged the length of boom (BC) and mast (AB) remains fixed so the proportion can be written:

Compression in boom equals constant times weight. That is, if AB equals BC then the force of compression acting in the boom will be equal in value to W. If the boom is one-half as long as AB, the compressive stress in the boom will be one-half W. Once the ratio BC to AB is known we can tell at once the compression in the boom for a given weight, regardless of the angle the boom makes with the mast.

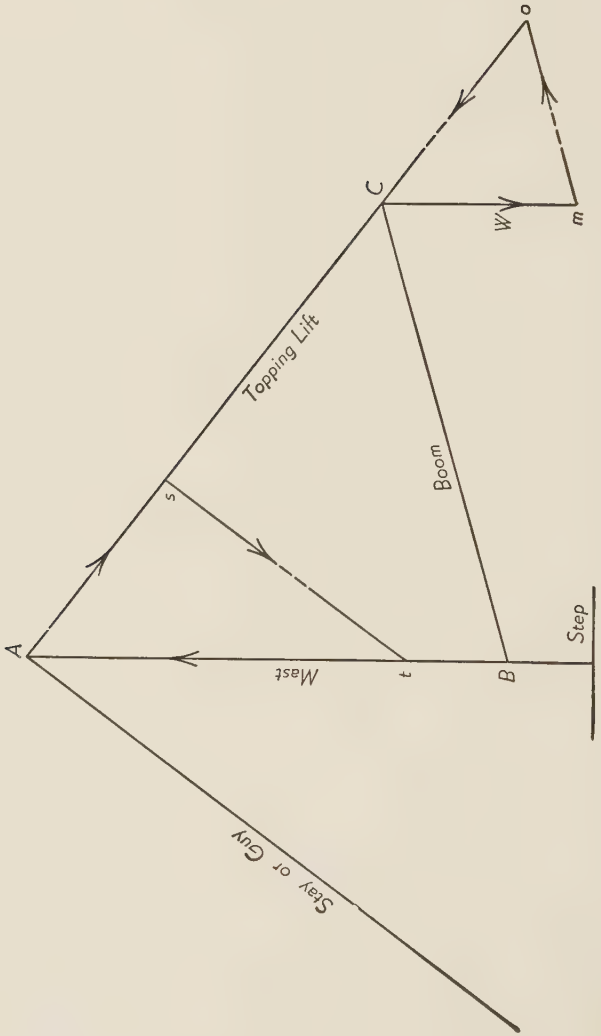


FIGURE 1.

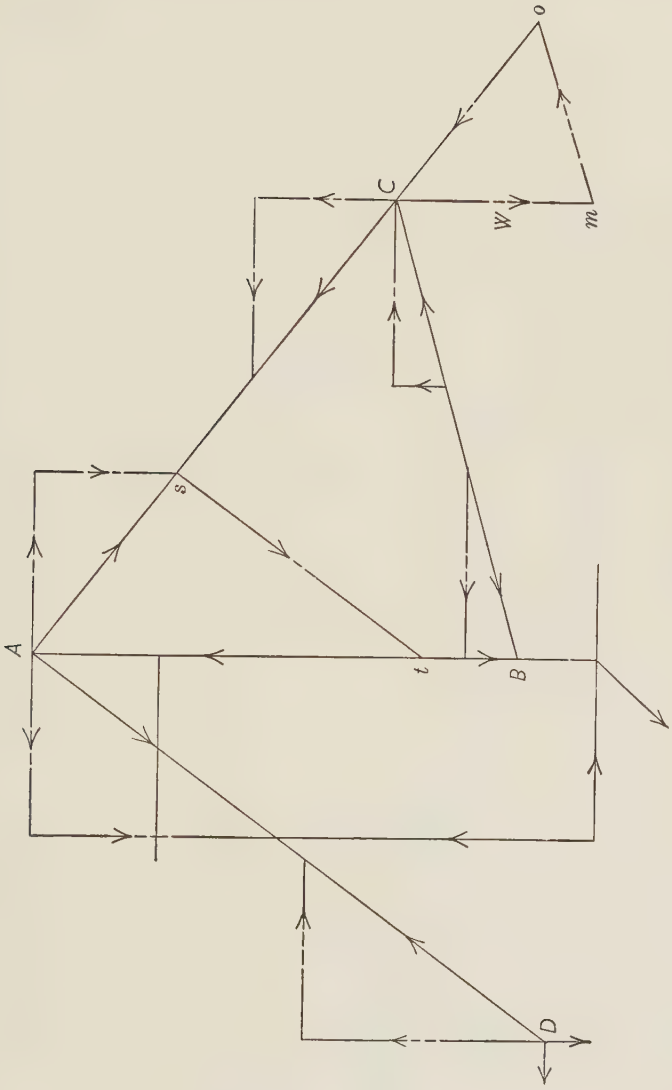


FIGURE 2.

To determine the tension on the topping lift: (Plate **34.** Fig. 1.)

$$\frac{Cm}{AB} = \frac{Co}{AC} \text{ or}$$

$$\frac{\text{Weight}}{\text{length } AB} = \frac{\text{Tension in topping lift}}{\text{length of topping lift}}$$

This shows that the shorter the topping lift (boom up) the less tension acts on it and the longer the topping lift the greater the tension on it.

There are times when it becomes necessary to handle extraordinarily heavy weights. Under these circumstances one is not only concerned with the extra heavy stresses on boom and topping lift but also the unusually heavy thrust on the mast step. Plate **35** shows such a rig for reducing the force on the boom, topping lift, and on the heel of the mast. It is to be noted that the heel of the boom should be fitted with a large shoe on deck to distribute the force over as large an area as possible and the deck under the heel well shored up.

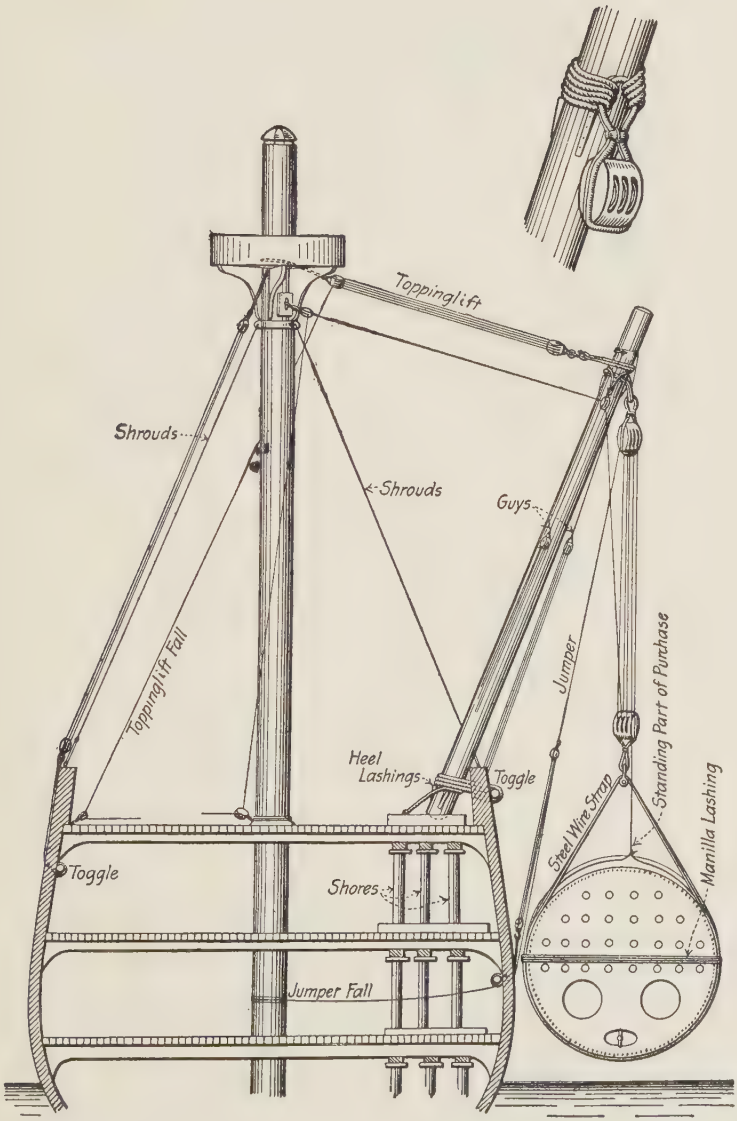
If the center lines of the mast and boom be extended to their point of intersection it will at once be apparent that Plate **35** is a simple boom and topping lift (Plate **36**). We can solve for the stresses in the boom and topping lift by measuring *AC*, *AB*, *BC* or by the expression:

$$\frac{W}{AC} = \frac{\text{Compression boom}}{BC} = \frac{\text{Tension topping lift}}{AC}$$

$$\frac{W}{5.10} = \frac{\text{Compression}}{4.88} = \frac{\text{Tension}}{1.88}$$

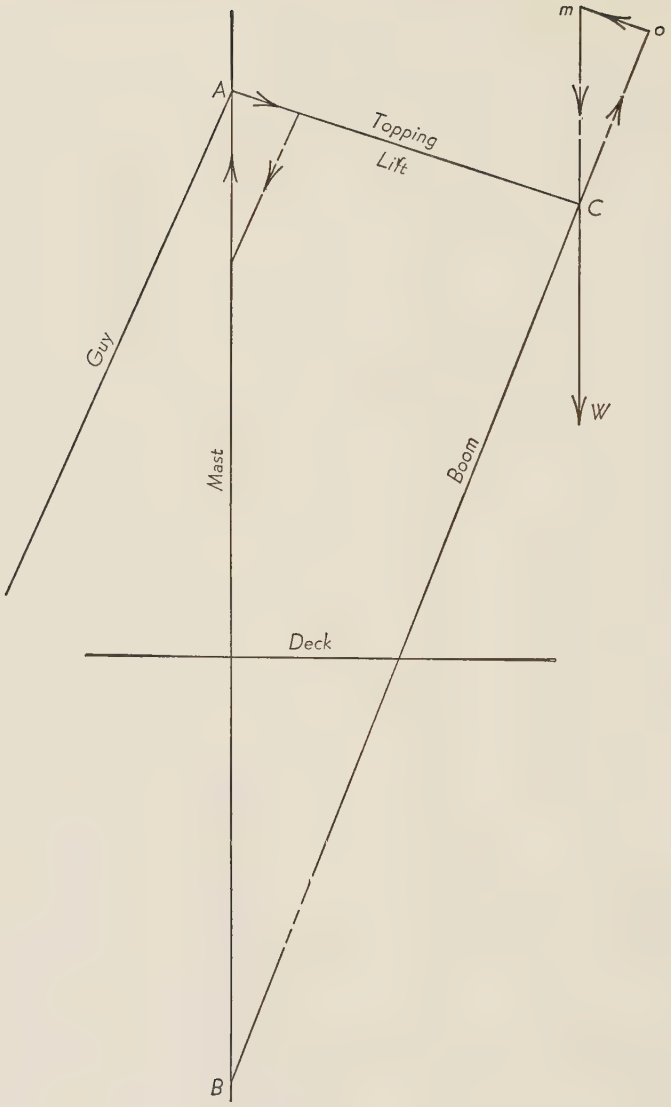
These equations give compression in boom of 0.96 *W* and a tension in topping lift of 0.37 *W*. These forces can easily be determined by a force triangle at *C*. Using a scale of one inch equal *W*, the triangle *Cmo* gives *Co* (compression in boom) as 0.95 *W* and *mo* (tension in topping lift) as 0.36 *W*. The forces acting at *A* can be found from the force triangle drawn at *A* using the known force of tension acting in the topping lift (see (Plate **37**).

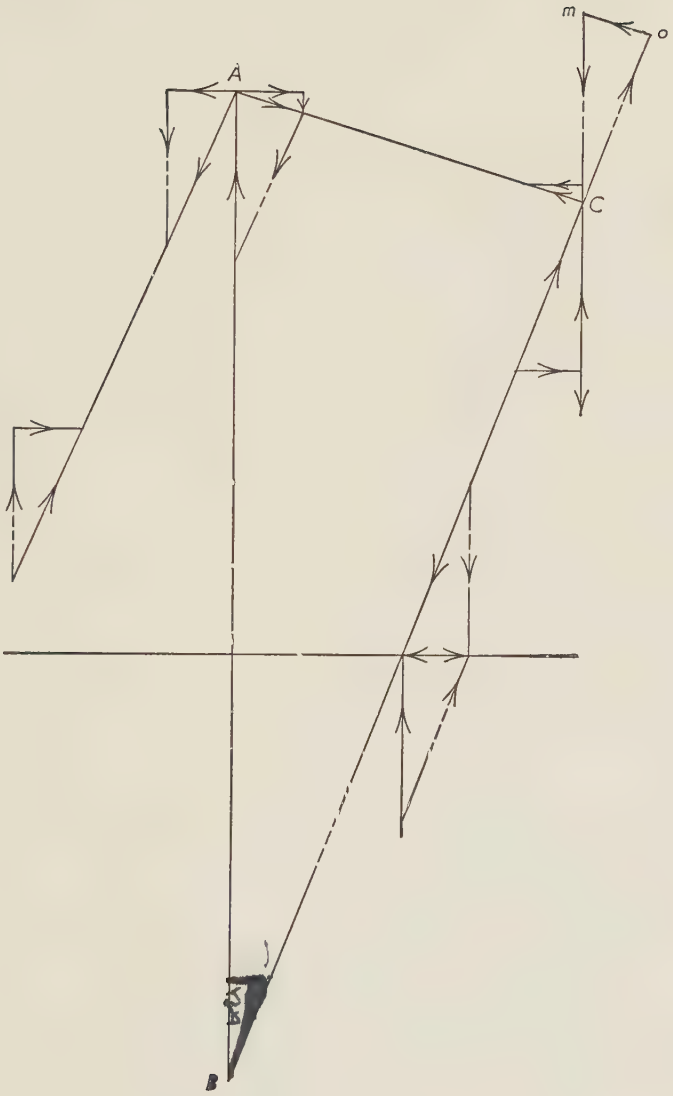
The vertical component of the thrust of the boom on deck is (by measurement to scale one inch equal *W*) 0.9 *W*. The shore under the deck at this point must support 0.9 *W*. This leaves



RIGGING A DERRICK FOR A HEAVY WEIGHT.

Plate No. 36




m
o
A
C
B

only the thrust of the mast at A unbalanced. By coincidence, this is equal to W, therefore, at B there must be a force equal to W to oppose the downward thrust of the heel of the mast.

Shear Legs.

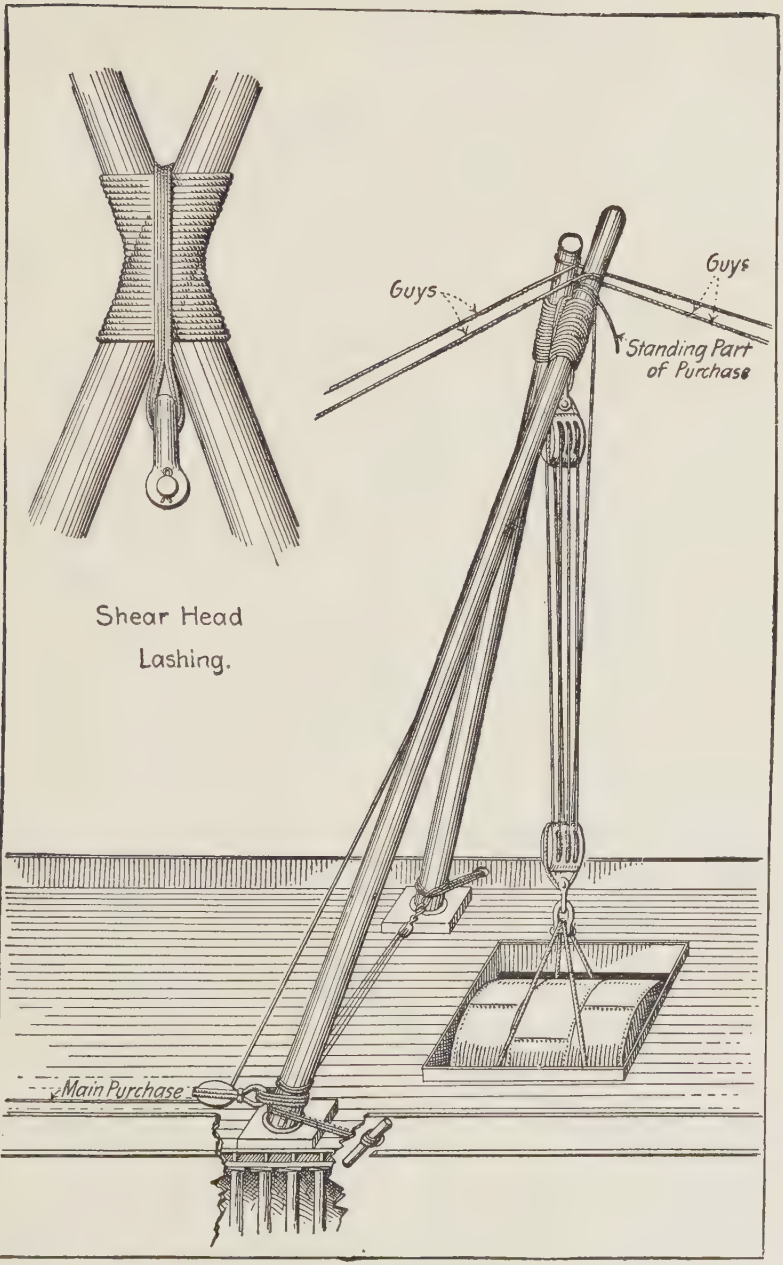
When it is necessary to handle weights in such a position on board ship that the rigging of special gear is necessary, it is often convenient to use shears.

To rig shears: lay the spars on deck, side by side, heels of spars even. Lash the spars with round lashing and pass a strap around the lashings for securing the purchase. Spread the legs so that the distance between the heels is about one-third the length of a shear leg from heel to lashing in order to give it a good stand. The heels of the spars should be stepped into shoes large enough to distribute the weight over a large area of the deck. In extreme cases it is necessary to shore up the deck under the shoes. Lead guys fore and aft as nearly perpendicular as possible to the plane of the shears.

Plate **38** shows shears rigged; it is assumed that the plane of the shear legs is inclined 30 degrees to the vertical. Fig. 1 of Plate **39** is a side elevation of the shears made on the plane through the line of action of the weight W and a line drawn from the shear head to the mid point on the line between the heels of the shear legs. To simplify the discussion make the plane of Fig. 1, Plate **39**, a plane of symmetry and let AB represent the line of action of the resultant of forces that act in the shear legs. CB and $C'B$ represent the line of action of the forces acting in the guys led in the direction of CB or in the direction $C'B$.

From point B (Fig. 1) draw the line of action of the weight W and indicate the direction of action of W by an arrow head pointing downward. To a scale one inch equal W, lay off a distance Ba equal W. Parallel to CB draw ab. The force triangle is Bab. Put in the arrows, head to tail, around the force triangle based on the known direction of W and they show ab (CB) in tension and bB (AB) in compression. On a scale of one inch equal W, ab equals 0.8 W and bB equals 1.52 W. But remember that these forces are the resultants of the forces acting in the shear legs and guys.

Had the guy (Fig. 1), CB, been led so that it was perpen-



SHEARS FOR HANDLING A HEAVY WEIGHT.

dicular to the plane of the shear legs as $C'B$, then the tension in the guys would have been a minimum. This can readily be seen by reference to the force triangle Fig. 1. The line marked (2) in this figure is the shortest line that can be drawn from a to AB, because it is the perpendicular from a to AB. Had the plane of the guys been perpendicular to the plane of the shear legs, then ac would represent (to scale) the resultant of tension in the guys, ac is 0.49 W. Hence the rule—Always lead the guys so that their plane is as nearly perpendicular as possible to the plane of the shear legs.

To find the forces acting in the shear legs (Plate **39,** Fig. 2), Bb was found from Fig. 1 and represents the resultant of the forces acting in the shear legs. From B' lay off $B'A'$ equal to Bb; lay off A'' as the mid point of BA'. Measure the distance between the heels of the shear legs and lay off through A'' on a line perpendicular to $B'A'$ the distances A_2A'' and A_1A'' equal to half the distance between the shear legs. Draw $B'A_2$, A_2A', $A'A_1$, A_1B'; in this parallelogram $B'A_2$ and $B'A_1$ represent (to scale) the forces acting in each shear leg. $B'A_2$ and $B'A_1$ are (0.87 inch) equal to 0.87 W. In other words, we know the resultant bB and from this resultant the parallelogram of forces was constructed to find the force acting in each leg.

Figure 3 represents the parallelogram of forces constructed by knowing the resultant (ab) of force acting on the guys whose plane is CB.

Assuming that the guys make equal angles with the plane of symmetry CBW (Fig. 1) at the shear head, draw a line $B''C''$ equal in length to ab. At B'' and C'' draw lines intersecting $B''C''$ at angles equal to one-half the angle between the guys at the shear head. Produce these lines until they intersect at C_2 and C_1. $B''C_2C''C_1$ is the parallelogram of forces whose resultant is $B''C''$ (equal to ab). $B''C_2$ and $B''C_1$ are 0.5 inch (equal to 0.5 W).

When the guys do not make equal angles with the plane of symmetry, then the two sides of the resulting parallelogram of forces will be unequal, so the forces acting in each guy will be unequal.

Notice that the length of the guys does not affect the forces acting in each guy. This can only be affected by the angle at which these intersect each other.

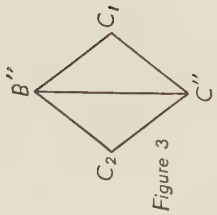


Figure 3

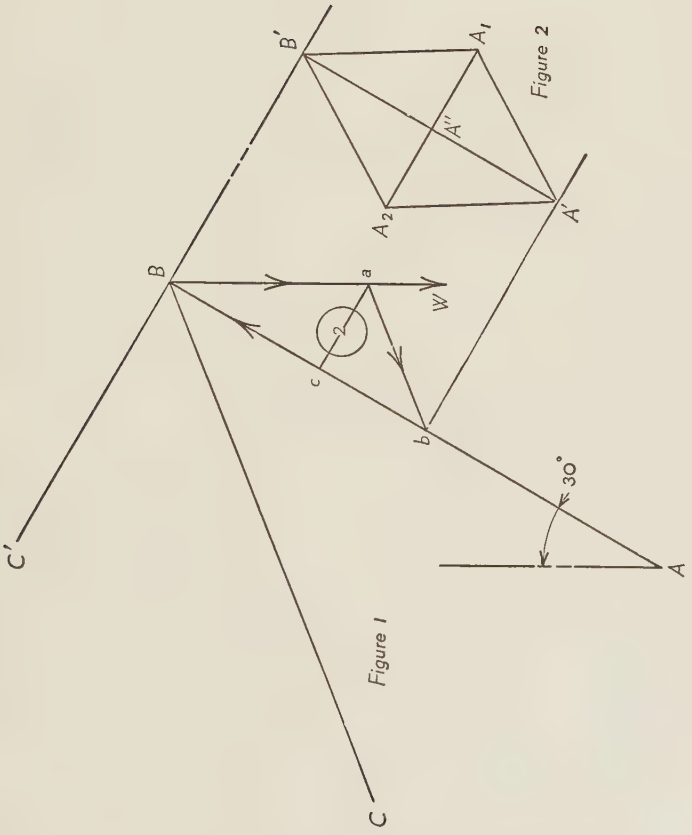


Figure 2

Figure 1

Summarizing:

Keep the plane of the shears as near the vertical as practicable.

Keep the heels of the shear legs as close together as practicable yet still give the sheers a good stance. A good ratio is to have the distance between the heels equal to one-third the length of a shear leg (from heel to lashing).

Lead the guys so that their plane is as nearly perpendicular to the plane of the shear legs as practicable.

Lead the guys so that they intersect the plane of symmetry of the shears at equal angles.

The Span.

The span is used by vessels having the yard and stay method of handling cargo (Plate **40**).

A span is frequently used in confined spaces where it is necessary to move a weight in a vertical direction and then in a horizontal direction, as for example pulling a pump out of its well, then moving it under a hatch.

Other examples of the span are:

(*a*) A vessel moored and riding with her keel at an angle to her line of anchors.

(*b*) A round turn (strap) passed around a spar (yard). The turns should be loose so as to make the angle *BOC* (Plate **41** Fig. 1) as acute (small) as practicable.

(*c*) In carrying out a heavy anchor (Plate **129**).

Let *B* and *C* (Plate **41**, Figure 1) be the point at which the blocks for the span are secured. The falls from the blocks at *B* and *C* are joined at *O*. *BW* represents the falls from *B* to *W* supporting the weight *W*. Raise the weight *W* to W_1 then suppose it is required to have the weight travel the straight line *OO'O''* until it is hanging vertically from the falls from *C*. We want to find the forces acting in *BO* and *CO*. Since the force *W* is pulling down, draw the arrow W_2 pointing downward. Lay off *Oa* equal to *W* to scale (one inch equal *W*.) Draw *ab* parallel to *BO* and prolong *OC* to *b*, the point of intersection of these two lines. In the triangle *Oab* draw in the arrows, head to tail, based on the arrow *Oa*. The direction of the arrow heads (pointing away from *O*) shows that *BO* and *OC* are in tension. By measuring *bo* and *ab* to scale, the tension in *OC* and *OB*

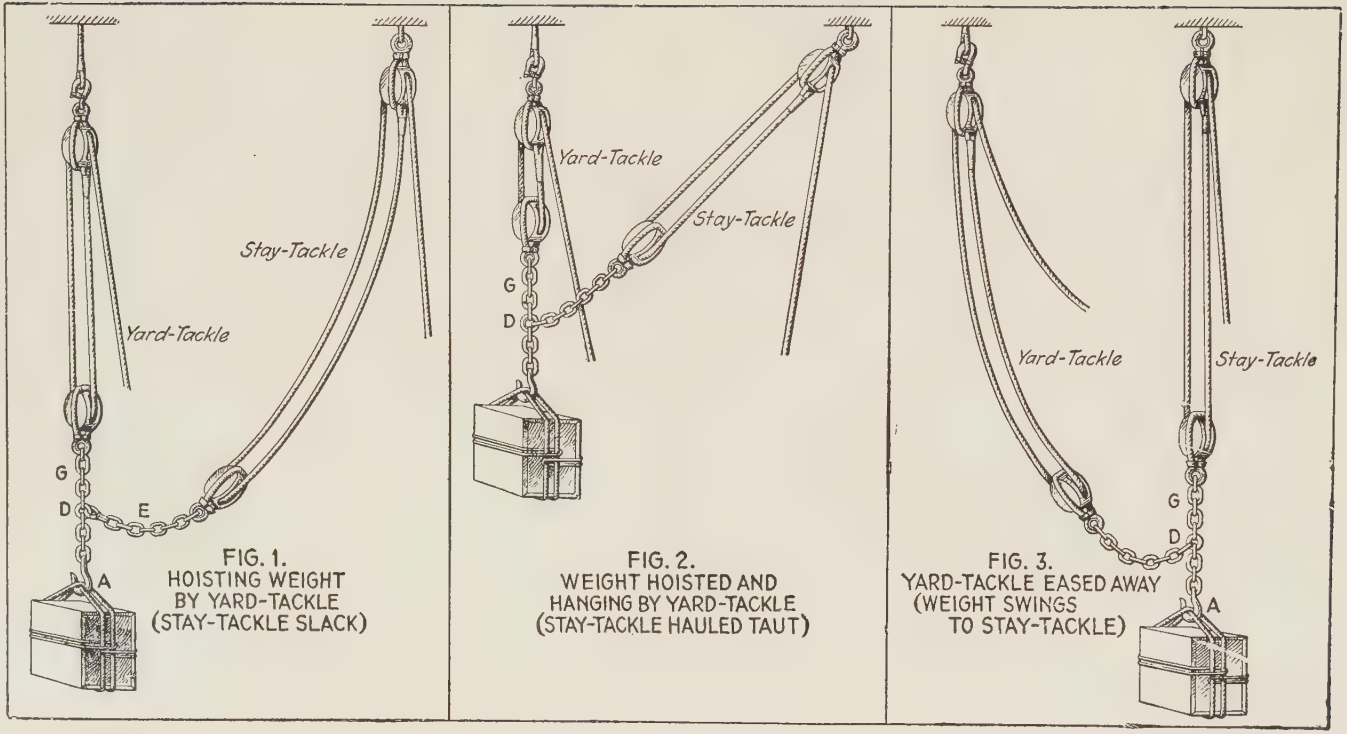


FIG. 1.
HOISTING WEIGHT
BY YARD-TACKLE
(STAY-TACKLE SLACK)

FIG. 2.
WEIGHT HOISTED AND
HANGING BY YARD-TACKLE
(STAY-TACKLE HAULED TAUT)

FIG. 3.
YARD-TACKLE EASED AWAY
(WEIGHT SWINGS
TO STAY-TACKLE)

YARD AND STAY TACKLES.

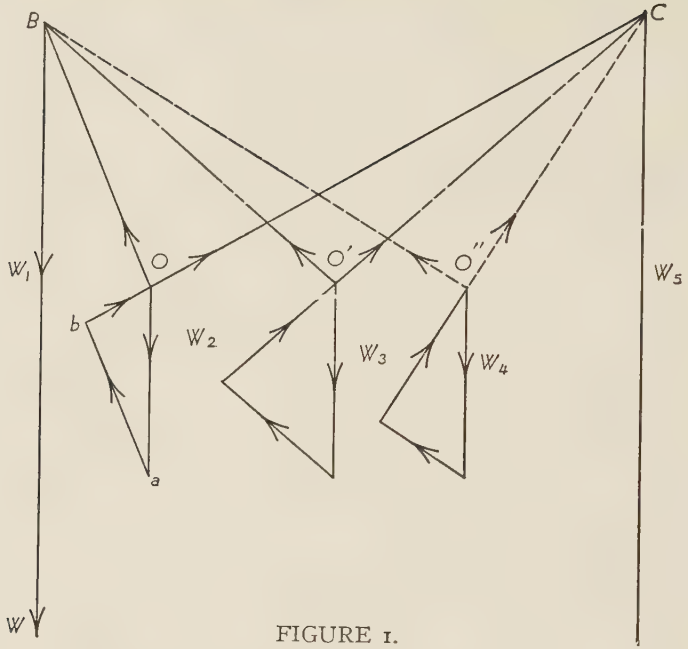


FIGURE 1.

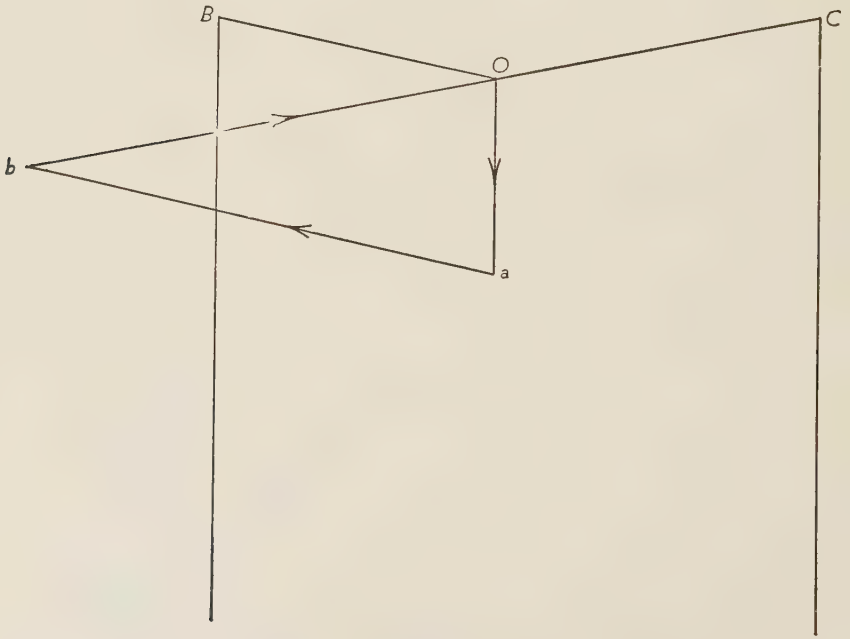


FIGURE 2.

can be found. In this case tension in OB (ab) is 0.86 W and in OC (bo) is 0.39 W. Similarly at O' and O'' the tension can be found by drawing force triangles as at O. At O' on the perpendicular bisector of the lines BC the tension in each fall will be equal (0.76 W). At O'' the tension in $O''C$ is 0.84 W and in BO'' is 0.53 W.

If the angle BOC is large (Figure 2) then the forces in BO and OC will be excessive and even dangerous. Suppose B and C are two patent chain falls secured to a frame by beam clamps; that W is 2000 pounds and due to the small overhead space it will be necessary to raise W close to B before starting to work it over toward C. Two one-ton chain falls are available to use at B and C. At O (Figure 2) the tension in each fall will be 2.48 W (one inch equal W) or 5960 pounds. This stress exceeds the designated working load (2000 pounds) by 3960 pounds and may cause a hook or a link failure in one of the chain hoists. This dangerous situation can be eliminated by moving C closer to B, then when the weight has been shifted vertically under C move the chain fall from B to another point to the right of C. Repeat this several times if necessary in order to keep the angle BOC less than 120 degrees, then the stress in either OB or BC can never exceed the weight W.

Moving Weights.

The force diagrams that have been discussed considered the weights as simply hanging from the device in question. It is desired to point out the great danger of sudden jerks and the effect of sudden and large changes in the speed of hoisting or lowering weights.

The fundamental equation of force is:

$$\text{Force} = \frac{\text{Weight}}{\text{Gravity}} \times \text{Acceleration}$$

If a body that is being hoisted at a uniform speed is suddenly hoisted at a faster speed we have in effect increased its weight. To illustrate this: a body of weight W, being hoisted at a speed of 10 feet per second, is suddenly speeded up, so that it is being hoisted at 20 feet per second, one-half of a second later.

While this weight was being hoisted at a uniform speed, the force necessary to hoist it was just necessary and sufficient to overcome the force of gravity, so its acceleration must have been equal to that due to gravity, therefore the equation

$$F = \frac{W}{g} \times \text{Acceleration}$$

$$F = \frac{W}{g} \times g$$

or $F = W$

Where F = Force acting
W = Weight
g = Acceleration due to gravity

As soon as the body speeds up, the acceleration causing this increase in speed may be found from formula

V_0 = Initial velocity
V = Final velocity
a = Acceleration
F = Force acting
W = Weight
g = Acceleration due to gravity

$V = at + V_0$
$20 = a1/2 + 10$
$a = 2\ (20-10) = 20$
but the body was being hoisted against the force of gravity and accelerating 20 feet per second, therefore in the formula $F = \frac{W}{g}\ a$, a must equal 20 + 32.2 or 52.2

$$F = \frac{W}{g}\ (20 + 32.2) = \frac{W}{32.2} \times 52.2$$

$F = 1.62\ W$

This means that while changing the rate of hoisting the weight, instead of handling a weight of W you are lifting a weight 1.62 times as great as W.

On the other hand, suppose you are lowering a weight at a speed of 15 feet per second and you bring it to a stop in a space of two and a half feet. What force have you used?

$$F = \frac{W}{g} \times \frac{V^2}{2^s}$$

$$F = \frac{W}{32.2} \times \frac{15 \times 15}{2\ (2.5)} = \frac{W}{32.2} \times 45$$

$F = 1.4\ W$

V = Velocity of body at time force is applied.
s = space in which it is desired to bring body to a stop.

This means that in the last two and one-half feet the weight traveled, it weighed 1.4 times as much as it would weigh if put on scales.

Sudden changes in the speed of hoisting or lowering a weight will cause dangerous forces to be introduced into the system at great risk of serious casualty.

Blocks.

A "Block" in the nautical sense consists of a frame of wood or steel within which is fitted one or more sheaves (pulleys).

Blocks take their names from the purpose for which they are used, the places they occupy, or from some peculiarity in their shape or construction. They are further designated as single, double, or triple blocks, according to the number of sheaves they have.

The size of a block is determined by the circumference of the rope to be used with it. For manila rope the size of the block in inches is three times the circumference of the manila rope; the diameter of the sheave is twice the circumference of the manila rope. Thus a block for use with a three-inch manila rope would be (3 times 3) a nine-inch block, and its sheave would be (2 times 3) six inches in diameter.

Blocks for use with wire rope are not so well standardized. Wire rope can now be made to conform to widely varying specifications. When specifications for blocks are drawn the advice of the manufacturer should be followed as to diameter of sheave or drum over which the wire is to be rove and the speed of operation (linear speed of the wire). If such advice is not followed the life of the rope will be materially shortened due to alternate bending and straightening as the wire passes over the sheave (drum).

The usual procedure is to base the diameter of sheaves and drums on the diameter of the rope which is to be used thereon. This procedure is technically correct because the diameter of the wires in a rope is a linear function of the diameter of the rope. The bending stress in a wire rope is a function of the wires and diameter of the sheave or drum. A preferable procedure from a practicable standpoint would be to base the sheave or drum diameter on the breaking strength of the rope. If a

sheave or drum diameter is chosen such that the bending stress is 10 per cent of the breaking strength, a reasonable load stress may be applied with a good factor of safety. This is a proper criterion of minimum diameter to follow in the design of sheaves or drums; the diameters of sheaves associated with wire ropes should be as large as practical considerations permit. The values given here are the minimum values of the ratio of diameter of the sheave at the bottom of the score (tread diameter) to the diameter of the wire rope used.[1]

Construction	*Minimum Diameter Ratio*
5 × 19	20
6 × 7	28
6 × 12	14
6 × 19	20
6 × 24	14
6 × 37	14

Tackle.

An assemblage of ropes (falls) and blocks for the purpose of multiplying force is a tackle (Plates **42** and **43**).

The seaman speaks of "reeving" when he passes ropes around the sheaves of the blocks. These ropes are called "falls." The "standing part" is that part of the fall made fast to one of the blocks. The hauling part is the end of the falls to which force is applied to handle the weight. To "overhaul" the falls is to separate the blocks. To "round in" is to bring the blocks together. The blocks are said to be "chock a block" or "two-blocked" when they are tight together.

Tackles are designated either according to the number of sheaves in the blocks that are used to make the tackle; as, single, two-fold, three-fold purchases; or, according to the purpose for which the tackle is used; as yard-tackles, stay-tackles, fore-and-aft tackles. Other designations handed down from the past still persist, as luff-tackles, gun-tackles, Spanish-burtons. (See Plates **42, 43**).

A *single-whip*. (Fig. 1, Plate **42**). A single block fixed.

A *runner*. (Fig. 2, Plate **43**). A single block movable.

[1] From Technical Bulletin No. 1–30 of the Bureau of Construction and Repair, U. S. Navy.

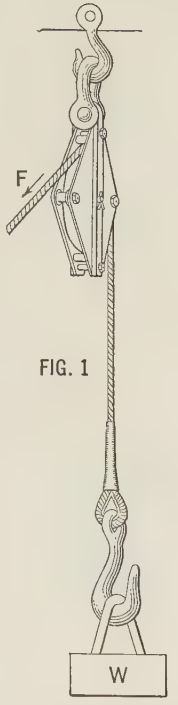


FIG. 1

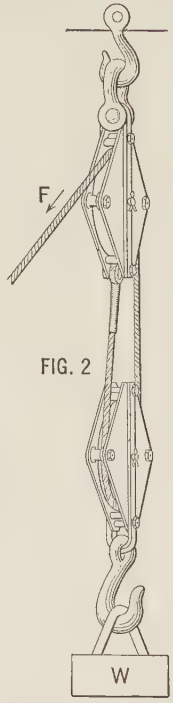


FIG. 2

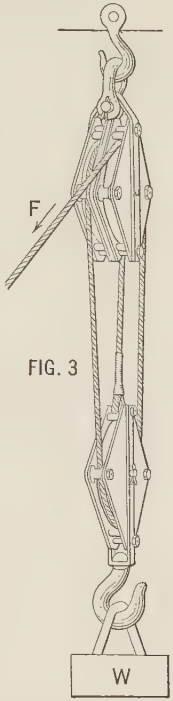


FIG. 3

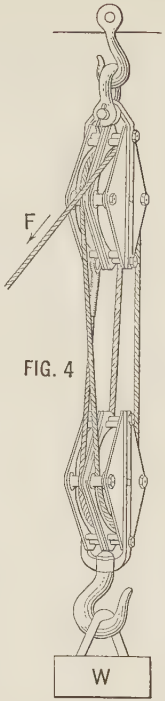


FIG. 4

FIG. 5

RATIO OF WEIGHT, W TO FORCE F NECESSARY TO RAISE WEIGHT.

	Disregarding Friction.	Allowing for Friction.
FIG. 1	$F = W$	$\frac{F}{W} = \frac{11}{10}$
FIG. 2	$\frac{F}{W} = \frac{10}{20}$	$\frac{F}{W} = \frac{12}{20}$
FIG. 3	$\frac{F}{W} = \frac{10}{30}$	$\frac{F}{W} = \frac{13}{30}$
FIG. 4	$\frac{F}{W} = \frac{10}{40}$	$\frac{F}{W} = \frac{14}{40}$
FIG. 5	$\frac{F}{W} = \frac{10}{50}$	$\frac{F}{W} = \frac{15}{50}$
In a three-fold purchase	$\frac{P}{W} = \frac{10}{60}$	$\frac{F}{W} = \frac{16}{60}$

NOTE: In this plate the hauling part leads from the fixed block. The mechanical efficiency can always be increased if the hauling part is lead from the movable block.

TYPES OF TACKLES.

A *whip and runner* would be a whip hooking to the hauling part of a runner.

A *gun-tackle purchase.* (Fig. 2, Plate **42**).

A *luff-tackle.* (Fig. 3, Plate **42**). A single and double block.

A *luff upon luff.* The double block of one luff-tackle hooked to the hauling part of another, thus *multiplying* the power.

A *two-fold purchase.* (Fig. 4, Plate **42**). Two double blocks.

A *double luff.* A double and treble block. (Fig. 5, Plate **42**).

A *three-fold purchase.* Two treble blocks. (See Plate **44,** in which two purchases are shown.)

A three-fold purchase is the heaviest purchase commonly used on shipboard.

The following are some of the purchases commonly used, designated by terms descriptive of their use, without reference to the blocks or sheaves involved:

Relieving-tackles are used to assist or replace the tiller ropes in steering. One block hooks to the tiller, the other to the ship's side.

Stock-and-bill-tackles are used in getting the anchors on and off the bill board in old-fashioned ships. They hook to straps on the stock and bill of the anchor respectively, and lead across the deck.

Thwartship-tackles are used on the heads of boat-davits for rigging in. In a more general sense the term is applied to any tackle leading across the deck. Similarly, a tackle for hauling out the backbone of an awning or for any other purpose where it has a fore-and-aft lead is a *fore-and-aft* tackle.

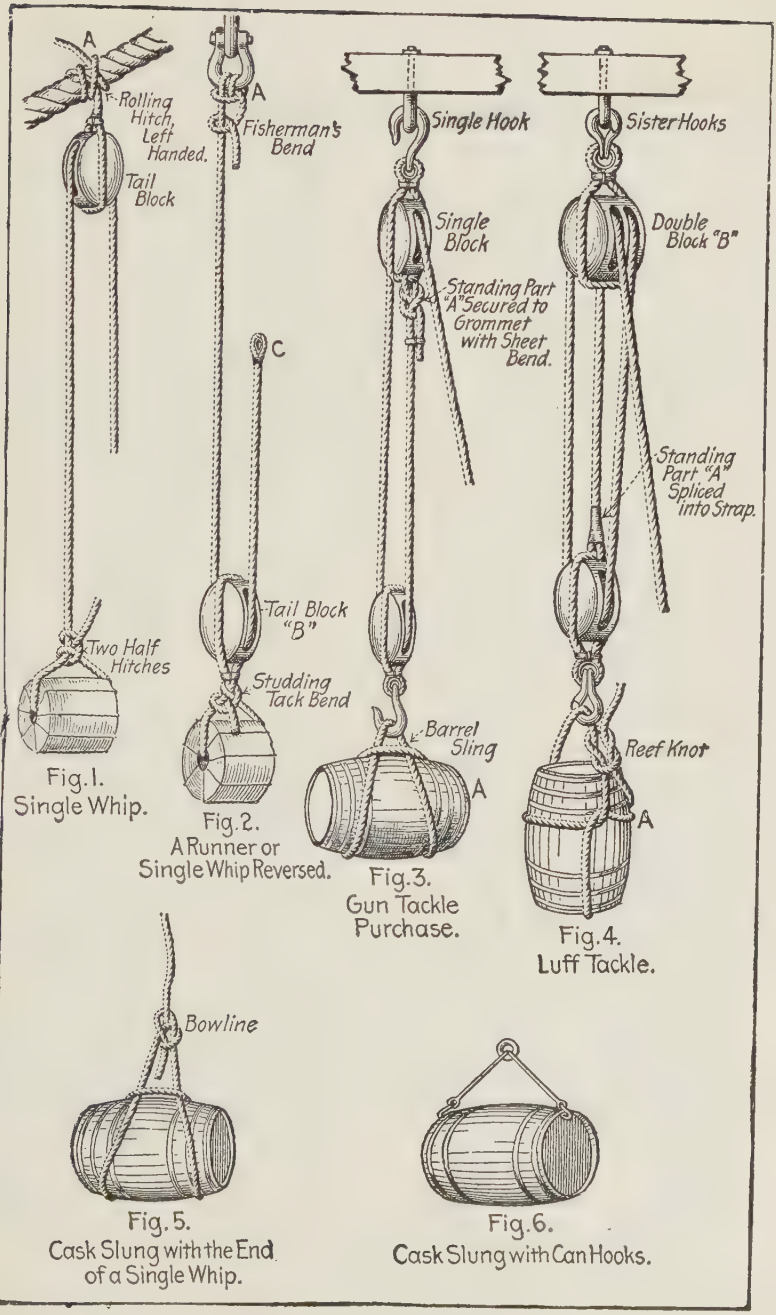
Hatch-tackles are used at hatches, for hoisting, lowering stores, etc.

Jiggers are small light tackles used for miscellaneous work about the ship.

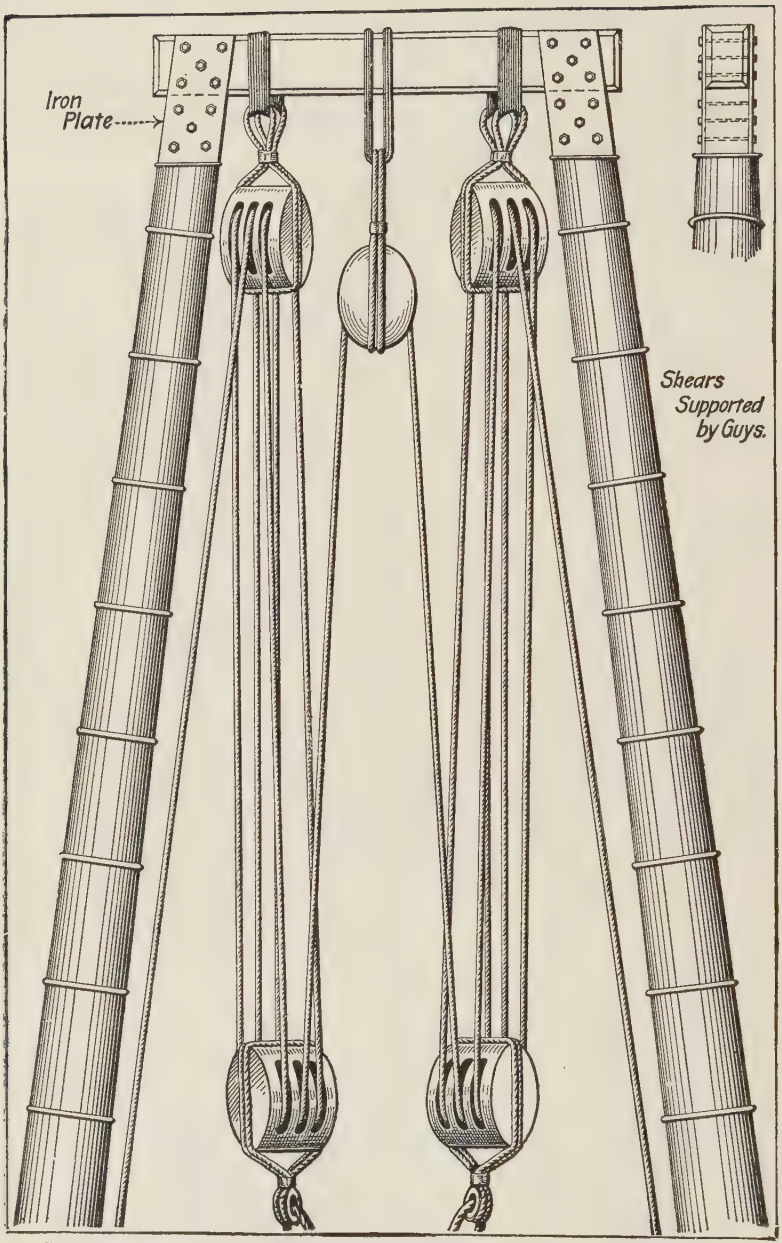
A *deck-tackle* is a heavy purchase, usually two-fold, used in handling ground-tackle, mooring ship, and generally, for heavy work of any kind about the decks.

Plate **44** shows a special purchase which may be used for very heavy weights. The tension on the various parts of the fall is partially equalized, by applying the power to both ends.

Yard and stay tackles take their names from their application on ships with masts and yards, where they were used together for transferring stores from a boat alongside, to the deck or

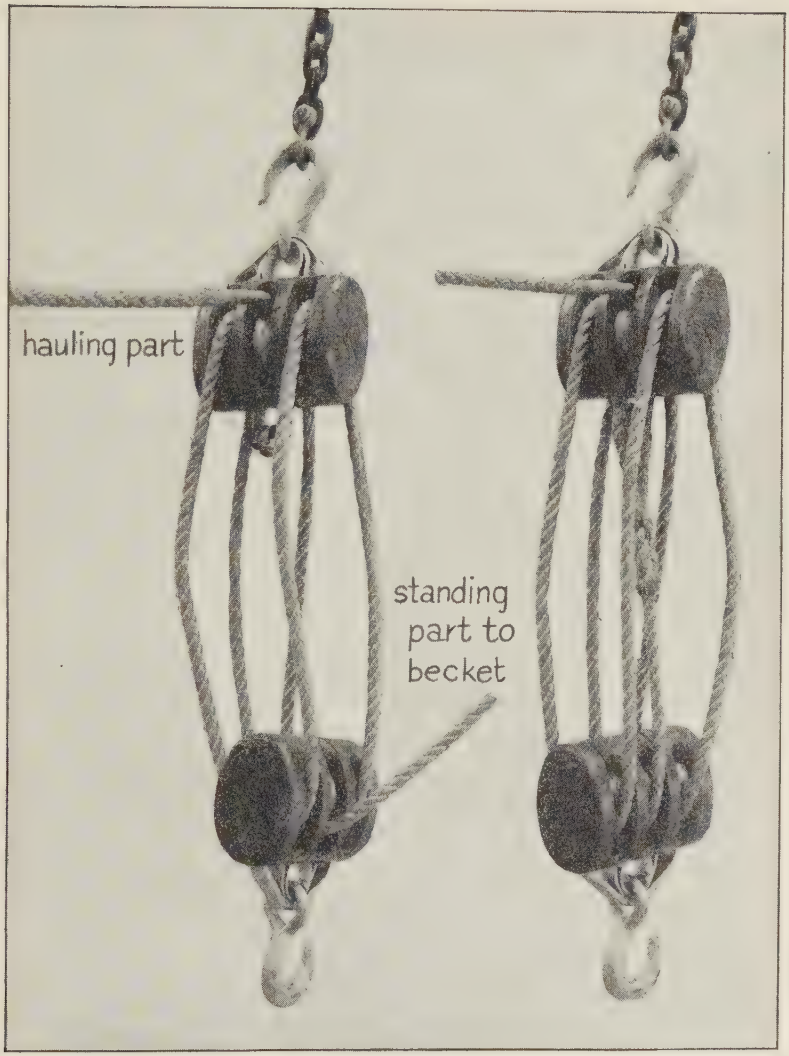


TACKLES IN USE.



SHEARS WITH DOUBLE THREE-FOLD PURCHASE FOR HANDLING HEAVY WEIGHT.

Note. The rope straps shown in use for very heavy work should preferably be of wire. Even where iron-strapped-blocks are available they are less reliable than if strapped with wire rope, though they are, of course,



RIGGING THE THREE-FOLD PURCHASE.

hatch of the ship. The yard tackle was hooked at the yard arm, where it could plumb the boat, and the stay tackle was hooked to a strap aloft and amidships, usually on the collar of the main-stay, from which point it plumbed the main hatch. (Plate **40**, Fig. 3.)

The tackles shown in Plates **42** and **43** are easily rigged. To the uninitiated, the three-fold purchase (Plate **44**) is difficult to rig and is explained herewith (Plate **45**).

Take two treble blocks, put one on deck, resting on its cheek (axis perpendicular to the deck); the other one rests on deck on its sheaves (axis parallel to deck). The axes of the two treble blocks will now be at right angles to each other. Now reeve the falls as shown in Plate **45**.

Unless the hauling part of a three-fold purchase leads from the center sheave, when force is applied to the hauling part, the block from which this part leads will cant and the hauling part will bind on the cheek. Under extreme circumstances, the hauling part when led from an end sheave will exert enough side thrust on the cheek to break the block. For these reasons always reeve the falls so that the hauling part leads from the middle sheave of one of the treble blocks.

When applying power to the hauling part of one tackle by means of another tackle the mechanical advantage of the system will be the product of the mechanical advantage of each system. To illustrate this, suppose you make a gun-tackle purchase fast to the hauling part of a two-fold purchase. There are four combinations of these tackles, viz., the two-fold purchase can be rigged so as to have a mechanical advantage of $\frac{1}{4}$ or $\frac{1}{5}$ and the gun tackle purchase can be rigged so as to have a mechanical advantage of $\frac{1}{2}$ or $\frac{1}{3}$. The following combinations could be used:

$\left(\frac{1}{4} \times \frac{1}{2}\right) = \frac{1}{8}$; allowing for friction $\left(\frac{14}{40} \times \frac{12}{20}\right) = \frac{168}{800}$ approximately $\frac{1}{5}$

$\left(\frac{1}{4} \times \frac{1}{3}\right) = \frac{1}{12}$; allowing for friction $\left(\frac{14}{40} \times \frac{12}{30}\right) = \frac{168}{1200}$ approximately $\frac{1}{7}$

$\left(\frac{1}{5} \times \frac{1}{2}\right) = \frac{1}{10}$; allowing for friction $\left(\frac{14}{50} \times \frac{12}{20}\right) = \frac{168}{1000}$ approximately $\frac{1}{6}$

$\left(\frac{1}{5} \times \frac{1}{3}\right) = \frac{1}{15}$; allowing for friction $\left(\frac{14}{50} \times \frac{12}{30}\right) = \frac{168}{1500}$ approximately $\frac{1}{9}$

In the definition of tackle the phrase "for the purpose of multi-

plying force" is used. To explain the significance of this phrase it is necessary to use the basic formulae of work.

$$f\,S = F\,s.$$

Where f represents a smaller force than F and s a smaller vertical height than S, thus in a two-fold purchase, if f acting through four feet (S) will raise a weight F one foot (s), we can write the fundamental equation:

$$f \times 4 = F \times 1$$

or $f = \frac{F}{4}$, the force (f) has been multiplied four times. The mechanical advantage of this purchase is four.

If friction is neglected there are two thumb rules that are useful in determining the multiplication of the force:

(a) Pass a plane above the block to which the weight is attached, the number of parts of the falls cut by this plane will be the ratio of force lifted to the force applied.

In Plates **42** and **43** the application of rule (a) will be readily seen. Observe though that if the two blocks of any purchase on Plate **42** were interchanged, that is the movable block made fast so as to become the fixed block and the weight attached to the other which would then be the movable block, the ratio of Force to Weight is changed to

Fig. 1,	Fig. 2,	Fig. 3,	Fig. 4,	Fig. 5
½	⅓	¼	⅕	⅙

Therefore, when practicable, make the block having the greatest number of sheaves the movable block. When the two blocks have the same number of sheaves, rig the tackle so that the hauling part leads from the movable block.

(b) Rig a tackle similar to the tackle in question. Place sufficient weight on the movable block to take all the slack out of the falls and let it just touch the deck; make a reference mark on the hauling part of the falls. Pull on the hauling part until the weight has been raised one foot, measure the amount of line taken on the hauling part. This amount of line (in feet) will be the ratio of force lifted to force applied.

Friction is allowed for practically by adding ten per cent of the weight to itself for each sheave passed over by the falls.

To illustrate: a two-fold purchase with its hauling part led from the fixed block and to the source of power through a fair lead has a theoretical advantage of 1 to 4. Since the falls go over five sheaves, allowing friction as ten percent per sheave will add fifty per cent (5×10) of W to the weight W. Then the tension on the hauling part instead of being $\frac{W}{4}$ would be,

$$(W + \frac{50W}{100}) \times \frac{1}{4} \text{ or } \frac{15W}{40}$$ (See Plate **36**).

When hoisting, the maximum tension will be on the hauling part; in lowering the maximum tension will be on the standing part. These effects are caused by friction which always acts to oppose motion. As an illustration, consider the luff tackle. If a weight of W pounds is suspended motionless from the purchase (Fig. 4, Plate **43**), the strain on all falls is $\frac{W}{3}$. If the weight is hoisted the strain on the hauling part is increased by friction from $\frac{W}{3}$ to $\frac{13W}{30}$ an increase of $\frac{3W}{30}$ but the strain on the standing part is still $\frac{W}{3}$ because friction has not acted on it. These conditions are just reversed when lowering.

If the whip (Fig. 1, Plate **46** and plate **42**) is suspended from a yard and the hauling part is secured on deck, the tension on the strap of the block will be $2W$, whereas if the hauling part were secured to the weight itself, the tension on the strap would be W.

To prove this, suppose one end of the whip is supporting a weight of W pounds and the other end secured on deck. Since the whip is flexible the tension in the hauling part must be equal to the tension in the part supporting W. Therefore the tension (T) throughout the length of the fall is constant. Since the weight is not moving the two forces (T and W) acting on the weight must be equal and opposite. Therefore T equals W. Taking moments about an end of the diameter perpendicular to the strap

$2\,r\,T = r\,F$ where F is the force acting on the strap but $T = W$, therefore $2\,r\,T = 2\,r\,W = r\,F$

$$\text{or } F = \frac{2\,r\,W}{r} = 2\,W$$

Figure 2

Figure 1

Had the hauling part been secured to the weight instead of the deck, then the tension in each part of the whip would have been equal to one half W (T equals $\frac{W}{2}$)
and taking moments as before

$$2\,r\,T = r\,F$$

but T now equals $\frac{W}{2}$

therefore $2\,r\,T = 2\,r\left(\frac{W}{2}\right) = r\,F$

and $F = W$

When a line supporting a weight W is led over a spar and back down parallel to itself the spar will have to resist a downward pull of $2W$. This condition is identical with the preceding paragraph. If the hauling part is led off at any other angle (Fig. 2, Plate **46**), the tension (T) acting in the line will cause a resultant force to act on the spar. This resultant can be found by constructing a parallelogram of forces. A side of the parallelogram will have a direction parallel to that part of the line it represents; the magnitude of a side will be T. Since the line is supporting a weight of W pounds, the force acting on the end that is secured must also be equal to W. Therefore the tension (T) throughout the line is equal to W.

Should a round turn be taken around the spar before securing the hauling part on deck, the resultant force acting on the spar will be greatly reduced. The part of the line leading from the spar, and secured to the weight will still be subjected to a tension (T) equal to W. Friction will act, on the line around the spar, to reduce the force necessary on the hauling part to prevent the weight from moving. Therefore the tension on the hauling part will be very much less than the tension in that part of the line from the spar to weight. The force acting on the spar as a result of these two unequal tensions will be considerably less than the force acting on the spar when no round turn was taken. This condition is indicated in Figure 2 of Plate **46.**

Patent Chain Hoists.

Various types of patent chain hoists (mechanical purchases) are used on board ship. Inasmuch as the chain hoists are classified according to the weight they are built to handle and their

mechanical advantage is so designed that one man can pull enough force to lift the weight for which they are designed, no discussion of the mechanical principles of their design is given here. Suffice to say that if the weight for which a given chain hoist is designed is exceeded, disaster is invited. Overloading usually makes itself apparent by requiring an unusually heavy pull to raise the weight, by the weight hook spreading, by the lifting chain parting. Overloading is to be carefully guarded against when using chain hoists as yard and stay tackles. (See discussion under Spans).

Strength of Ropes, Blocks and Tackles, etc.

When definite information is at hand with regard to the strength of the rope in question, it should of course be utilized. In the absence of such definite information, the following rules are convenient and safe:

B = Breaking stress, lbs. or tons (of 2240 lbs.).
P = Safe working load; viz., safe tension for single part of rope.
C = Circumference (inches).

Rule 1. Strength of manila or hemp.

$$B = \frac{C^2}{2.5} \text{ tons} = C^2 \times 900 \text{ lbs.}$$

Rule 2. Strength of wire.

$$B = C^2 \times 2.5 \text{ tons} = C^2 \times 5600 \text{ lbs.}$$

The breaking stress being known either from the above formulae or from other sources (see appendix), the working load adopted as safe for a single part of the rope (P, Plate **36**) will depend upon the factor of safety which we adopt after consideration of the condition of the rope itself and the use to be made of it.

The factor of safety may be taken as follows:

(a) **Under average conditions,**

Working load, P, = ⅙ breaking stress, B.

(b) **Under best conditions—new rope to be used occasionally,**

Working load, P, = ¼ breaking stress, B.

(*c*) **Under unfavorable conditions, where rope is used frequently and for an indefinite period, as in the case of running rigging and boats' falls,**

Working load, P, = ⅛ breaking stress, B.

If, without knowing the breaking stress in a given case, we wish to derive the safe working load directly from the circumference of the rope, we have the following:

Rule 3. Safe working load for manila or hemp.

Under average conditions:

$$P = \frac{C^2}{15} \text{ tons} = C^2 \times 150 \text{ lbs.}$$

Rule 4. Safe working load for wire.

Under average conditions:

$$P = \frac{C^2}{2.5} \text{ tons} = C^2 \times 900 \text{ lbs.}$$

Under best conditions, add 30% to above values of P.

Under very unfavorable conditions, subtract 30% from above values of P.

NOTE.—Observe that the working load for wire is the same as the breaking stress for manila.

Rule 5. Strength of Hooks and Shackles.

It may generally be assumed that the safe load for a well-made *block* is in excess of that of any hemp or manila rope that it will reeve. This, however, is not always true of the *hook,* which is almost invariably the weakest part, and often gives way under strains for which the block is otherwise amply strong. The strength of the hook is therefore the measure of the strength of the block. The difficulty here comes from the tendency of the hook to open out;—a tendency which should be guarded against, in heavy work, by careful "mousing" of the hook—preferably by an iron link.

For heavy work, *shackles* are fitted to blocks in place of hooks and are very much to be preferred, as will be apparent from the rules and tables which follow.

(*a*) *Hooks.*

D = Diameter at back of hook.

$P = \frac{2}{3} D^2$ tons.

(*b*) *Shackles.*

D = Diameter at sides.
$P = 3\ D^2$ tons.

NOTE.—For a given diameter of material, a shackle is approximately 5 times as strong as a hook.

The following table gives the results of practical tests made at the Watertown Arsenal. The hooks and shackles tested were of the ordinary commercial form. The diameter given is that of the metal at the back of the hook and the sides of the shackle.

TEST OF HOOKS.

Diameter of metal.	Broke at	Remarks.
½ inch	2,385 lbs.	Hook partly straightened, then fractured across the back.
¾ "	4,130 "	
1 "	10,315 "	
1¼ inches	14,510 "	
1½ "	20,940 "	
1¾ "	27,420 "	
2 "	38,100 "	
2½ "	55,380 "	

TEST OF SHACKLES.

Diameter of metal.	Broke at	Remarks.
¾ inch	20,700 lbs.	Eye of shackle parted.
⅞ "	38,100 "	" " "
1 "	51,900 "	" " "
1¼ inches	75,200 "	" " "
1½ "	119,980 "	" " "
1¾ "	146,400 "	Sheared shackle-pin.
2 "	196,600 "	Eye of shackle parted.
2½ "	210,400 "	" " "

Rule 6. To find the size of manila rope to lift a given load (in tons).

From Rule 3, above, we have

$$C \text{ (inches)} = \sqrt{15 \times P},\ \text{(tons)}.$$

Hence, multiply the load *in tons* by 15 and take the square root of the product for the circumference of the rope in inches.

NOTES.—Rule 6, above, gives an unnecessarily large factor of safety for the stronger types of wire, but it is convenient and safe.

A well-made splice weakens either manila or wire by from 5% to 10%.

A sharp nip may weaken manila or wire by from 25% to 50%.

Manila deteriorates rapidly if stowed away wet, or if exposed, either wet or dry, to continued high temperature.

Wire-rope should be discarded when its outer wires are worn down to one-half their original diameter.

The strength of two ropes of different sizes but similar construction is proportional to the *squares* of the circumferences. Thus a 2-inch rope is to a 3-inch as 4 to 9.

As a working rule, wire-rope is six times as strong as manila of the same size.

In cases where a load is applied suddenly, with a blow or a jerk, its effect is doubled, and this should be allowed for in calculating the size of rope required.

Rule 7. To find the size of wire rope to lift a given load. (6×12 type, Plate **21**)

From Rule 4, above, we have

$$C \text{ (inches)} = \sqrt{2.5 \times P}, \text{ (tons)}.$$

Hence, multiply the load in tons by 2.5 and take the square root of the product for the circumference of the rope in inches.

Rule 8. To find the size of rope when rove as a tackle to lift a given weight.

Add to the weight one-tenth of its value for every sheave to be used in hoisting. This gives the total resistance, including friction. Divide this by the number of parts at the movable block, for the maximum tension on the fall. Reeve the fall of a size to stand this tension as a safe working load.

EXAMPLE:

To lift 10 tons with a three-fold purchase, the fall of which, coming from the upper block, is taken through an extra sheave on deck for a fair lead. Required the size of fall needed.

Total resistance, including friction $= 10 + 7 \times \frac{10}{10} = 17$ tons.

Maximum tension on fall $= \frac{17}{6} = 2.8$ tons.

Size of fall (Rule 2) $= \sqrt{15 \times 2.8} = 6\frac{1}{2}$ inches (nearly).

Rule 9. To find the weight which a given purchase will lift with safety.

Find the safe-working load for the rope to be used (Rule 1). Multiply this by the number of parts at the movable block. This gives the total resistance including friction.

Multiply the total resistance by 10 and divide by 10 + the number of sheaves used. The result is the weight that may be lifted.

EXAMPLE:

To find the weight which may be lifted by a fall of $6\frac{1}{2}$-inch manila rope as a three-fold purchase, the fall of which leads from the upper block through an extra leader on deck.

Safe-working load, $\frac{6.5^2}{15} = 2.8$ tons $= P$.

Total resistance, including friction, $6 \times 2.8 = 16.8$ tons.

Weight to be lifted, $\frac{16.8 \times 10}{10+7} = \frac{168}{17} = 10$ tons approximately.

Rule 10. To find the strength of a spar to resist compression (derrick or shears).

T = Safe thrust in tons
R = Radius of spar in inches.
L = Length of spar in feet.

$$T = \frac{4R^4}{L^2}$$

NOTE.—The multiplier 4 in this formula is safe for all ordinary kinds of wood. For very strong woods, like oak, mahogany, etc., it could be increased 50 per cent without danger.

EXAMPLE:

To find safe thrust for a spar 10 inches in diameter, of fir, 17 feet long.

$$T = \frac{4 \times 5^4}{17^2} = 8.6 \text{ tons.}$$

CHAPTER VI.

THE COMPASS, LOG AND LEAD—RADIO DIRECTION-FINDER—SUBMARINE SIGNALS.

The Magnetic Compass.

The earth is an immense natural magnet with a pole in each hemisphere. A magnetic needle freely suspended at any point on the earth's surface, and undisturbed by other than the earth's magnetic influence will assume a position with its north-seeking pole pointing toward the earth's north magnetic pole. The mariners' compass is an instrument consisting either of a single magnet or of a group of magnets fixed to a graduated circle which is pivoted at the center and allowed to swing freely in a horizontal plane. When unaffected by the magnetic influences of the ship, the compass will lie with the north-seeking ends of the magnet or magnets pointing toward magnetic north.

The magnetic and geographic poles of the earth are not coincident, and a magnetic compass points to magnetic north and not true north. The angular difference between true north and the direction in which the magnetic compass points when uninfluenced by the magnetic properties of the ship is known as "variation." Further, on different headings, the magnetic properties of the ship cause the compass to point other than toward magnetic north, with varying degrees of error. The angular difference between magnetic north and the direction in which the magnetic compass points on any given heading is the "deviation" for that heading. "Variation" errors are accurately known for all points on the earth's surface, and "deviation" errors for the various headings of the ship may be more or less fully neutralized by the methods used to "compensate" the compass. It is well to note that compensation data for one approximate latitude is not necessarily correct for any other latitude.

Magnetic compasses may be either dry or liquid. In the dry compass the magnets are single wires suspended from the com-

pass card by silk threads. The compass card is also suspended by silk threads leading from a central boss. In this central boss is a jeweled cup which fits over a pivot rising vertically from the compass bowl.

In the liquid compass the magnets are secured directly to the card and to the central boss. This boss contains the jeweled cup which rests on the pivot rising from the compass bowl. This comparatively heavy arrangement is practically floated in a mixture of alcohol and water, or glycerin and water, in order to reduce the weight on the pivot and the resulting friction, and also to damp the movements of the card. The liquid compass has reached a high state of perfection and within the arbitrary limitations of any magnetic compass has many points in its favor. All magnetic compasses issued to vessels of the Navy are of the liquid type.

The Navy Standard 7½-Inch Liquid Compass. (Plate **47**).

This is a magnetic compass consisting of a skeleton card 7½ inches in diameter, made of tinned brass, on the under side of which are fixed four symmetrically placed magnets. The whole rests on a pivot in a nonfreezable liquid composed of 45 per cent alcohol and 55 per cent distilled water.

The magnet system of the card consists of four cyclindrical bundles of steel wires, placed parallel to the north and south diameter of the card, that have been magnetized between the poles of a powerful electromagnet. Steel wires made up in a bundle are more homogeneous, can be more perfectly tempered, and for the same weight give greater magnetic power than a solid steel bar.

The card is of a curved annular type, graduated to read to degrees, with legible figures at each 10°, from 0° to 350°, for use in reading bearings by an azimuth circle or in laying the course to degrees. In addition to the degree graduations, there are shown only the eight cardinal and intercardinal points. The "cardinal" points are north, south, east, and west; the "intercardinal" points are northeast, southeast, southwest, and northwest.

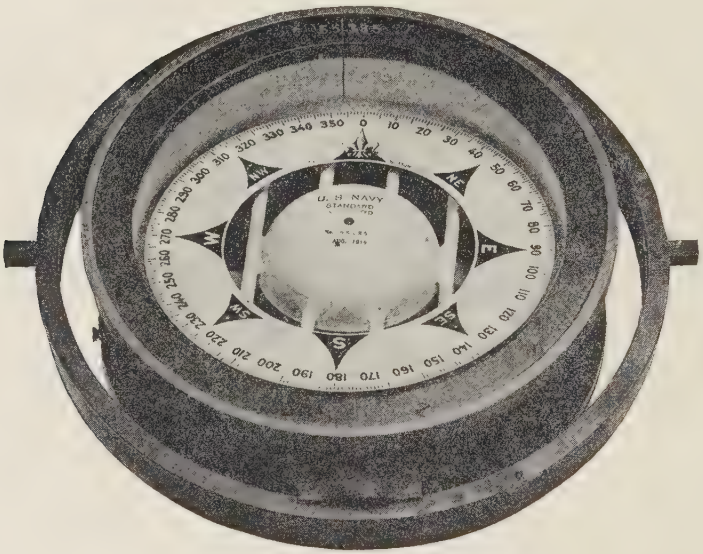
In the center of the card is a spheroidal air vessel to buoy the weight of the card and magnets. The air vessel is provided with a conical opening on the under side in which is a cup containing

a sapphire to form the bearing of the card on the pivot projecting upward from the compass bowl. The weight of the card complete is about 3,060 grains, but due to the buoyancy of the air vessel the pressure of the card on the pivot is reduced to between 60 and 90 grains at a temperature of 60°F.

Beneath the bowl and secured to it is an expansion chamber made of elastic metal. The bowl and expansion chamber are completely filled with liquid, and two small holes in the bottom

Plate No. 47

Figure 1.



COMPASS CARD AND BOWL.

of the bowl communicate with the expansion chamber and permit circulation of the liquid between the two. The bowl is thus kept full regardless of changes of temperature.

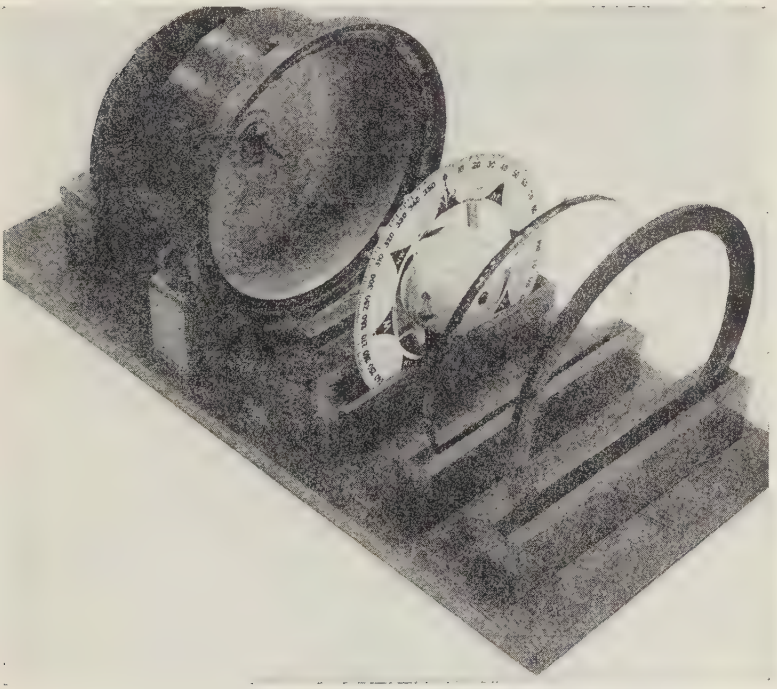
The bowl is covered with thick glass, under the edge of which is a rubber gasket to prevent leakage or evaporation. The outer and upper edges of the bowl are machined carefully in order that an azimuth circle will fit accurately. The bowl has a lead weight at the bottom, and is carried in gimbals. These gimbals enable the weighted bowl, and thus the compass card, to remain level while the ship is pitching and rolling. The bottom of the

bowl and card itself may be transparent in order that the card may be illuminated by a small light in the binnacle.

The inside of the bowl is painted with white insoluble paint, and marked with two black vertical lines 180° apart. The one toward the bow of the ship is called the "lubber's line." The compass bowl is mounted so that the line through the lubber's line and pivot point is parallel to the keel, then the point on the

Plate No. 47

Figure 2

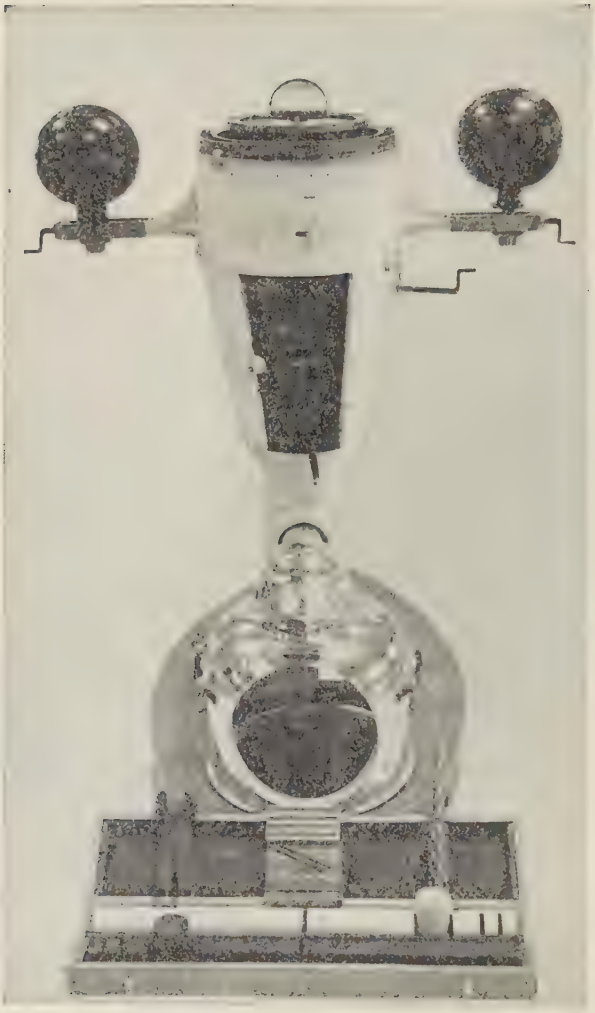


DISASSEMBLED MAGNETIC COMPASS.

compass card coinciding with the lubber's line gives the heading of the ship or the course being steered.

THE BINNACLE (Plate **48**).

The compass is mounted for use in a stand called a binnacle. That in general use in the Navy is called the "compensating binnacle" because it is equipped with the means for neutralizing or



COMPENSATING BINNACLE.

compensating the errors introduced into the compass by the magnetic materials on the ship.

It is important that magnetic material present when the compass is compensated shall not be removed, nor shall any magnetic mass even as small as a pocket knife be brought near the compass while it is in use, for to do so may so deflect the compass that the ship will be steered into danger.

Boxing the Compass.

To "box the compass" is to name the points and fractional parts of points from north, around by way of east, back to north. Old style compass cards were graduated only in points and fractional points, and courses and bearings were so designated. The points, half points, and quarter points are here listed for the quadrant from north to east; the other quadrants follow a similar sequence:

North to Northeast.	Northeast to East.
North	NE.
N. ¼E.	NE. ¼E.
N. ½E.	NE. ½E.
N. ¾E.	NE. ¾E.
N. by E.	NE. by E.
N. by E. ¼E.	NE. by E. ¼E.
N. by E. ½E.	NE. by E. ½E.
N. by E. ¾E.	NE. by E. ¾E.
NNE.	ENE.
NNE. ¼E.	ENE. ¼E.
NNE. ½E.	ENE. ½E.
NNE. ¾E.	ENE. ¾E.
NE. by N.	E. by N.
NE. ¾N.	E. ¾N.
NE. ½N.	E. ½N.
NE. ¼N.	E. ¼N.
NE.	East

The Gyro-Compass [1] (Plate **49**).

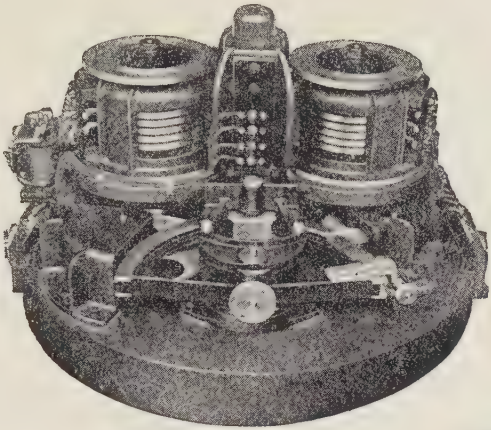
The gyroscopic compass has two distinct advantages over the magnetic compass: first, it is entirely independent of the earth's magnetic field and all the technical tables, instruments, and meas-

[1] Prepared by Asst. Prof. Frank E. La Cauza, Postgraduate School, U. S. N. A.

urements associated with it; second, it can be made to indicate the true geographical instead of the magnetic pole. Unfortunately, it is a complicated mechanism, and in case of casualty, requires expert technical attention; because of this, wherever gyro-compasses are used, magnetic compasses are still retained as auxiliaries. All important naval craft and most of the important merchant vessels today have a gyro-compass installation, the American equipment being either Sperry or Arma.

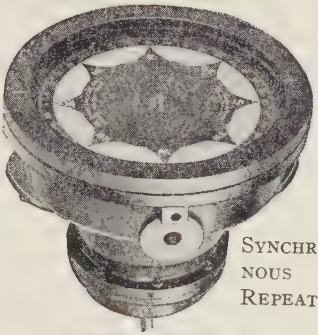
The heart of the gyro-compass is the gyroscope, which can be looked upon as a mass more or less concentrated in a plane and spinning about an axis perpendicular to that plane. When placed in gimbal rings, it has three properties: first, three degrees of freedom; second, rigidity of plane; third, precession. The first property refers to the ability of a gyroscope to be rotated about any one of three mutually independent axes independently of the other two. These three axes are termed the spinning, the horizontal, and the vertical. When a gyro-compass is operating normally, the spinning axis is parallel to the earth's surface and the meridian; the horizontal is parallel to the earth's surface and the lines of latitude; the vertical, points to the zenith. In the gyro-compass, by means of mechanisms controlled by the force of gravity, the freedom of motion about the horizontal axis is almost entirely suppressed in order to keep the spinning axis parallel to the earth's surface and the meridian.

The second property of the gyroscope—rigidity or fixity of plane—was discovered by Foucault in 1852. He showed that a wheel of high angular momentum tends to remain constantly in its plane of spin unless a force tries to turn it about any axis in its plane. This implies that the rotation of the earth does not affect it. In other words, if one end of the spinning axis were pointing at the sun, it would continuously point at the position of the sun in the sky both day and night; in fact, if the angular momentum were infinite, it would point at the sun or any other desired celestial body—such as the polar star—indefinitely. This property depends on the product of the mass, the speed, and the square of the radius of gyration. In the compass these are made as large as is practically possible. Knowledge of the principle of operation of the three-phase squirrel cage induction motor will show that this motor is well suited to make the product of these factors high, provided stator and rotor are the reverse of



Master Gyro-Compass

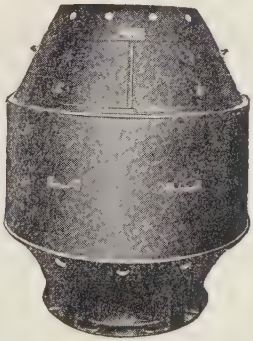
Repeater System Motor Generator



Synchronous Repeater

Control and Repeater Panel

Gyro-Drive Motor G



Master Gyro-Compass Enclosed in Binnacle

SPERRY MK IX GYRO-COMPASS SYSTEM.

the usual industrial induction motor in order to get a high radius of gyration.

The third property—precession—is observed when an attempt is made to turn a spinning gyro about some axis in the plane of the wheel. The wobbling of a top just before it stops is a good example of this property; in this case the precessing force is the pull of the earth on the center of gravity of a rotating object whose spinning axis is no longer vertical. A torque about the spinning axis will not produce precession; a torque about any other axis will. In the latter case, the spinning axis so moves as to tend to coincide with the axis of the precessing torque. Looked at in another way, a board pressed against one side of the spinning axis may be substituted for the precessing force; the direction of precession is such as would result by that side of the spinning axis rolling along the board if it were free to do so.

In order to keep the spinning axis of a gyro-compass always parallel to the meridian, it is necessary to precess it continuously except at the equator. One way to accomplish this is to allow gravity to act on a weight placed at the bottom of the wheel case; or what amounts to the same thing, allow it to act on the sensitive element center of gravity, which does not coincide with the center of rotation. This method makes the compass "pendulous," and is used by the Arma Company. Another method, used by the Sperry Company—the "mercury ballistic"—is to employ a U-shaped tube with vessels containing mercury at the ends, operating as if the bottom of the tube were rigidly attached close to the bottom of the wheel case. A slight dip of the spinning axis will transfer mercury from one vessel to the other, causing gravity to increase its pull on the lower vessel, thus producing precession. This method makes possible a "non-pendulous" compass, wherein the sensitive element center of gravity coincides with the center of rotation. Consideration of the foregoing will show that gravity acts on the precessing mechanism of the pendulous compass in a direction opposite to that of the non-pendulous compass; thus, looked at from the same point of view, it will be found that the Arma wheel turns in a direction opposite to that of the Sperry. These precessing torques make the gyro-compasses "north seeking."

Further study of what has preceded will show that while this

gravity torque has made a gyro-compass out of a gyroscope, the compass will oscillate from one side of the meridian to the other, and for practical use must be damped. The Sperry Company accomplishes this by designing the mercury ballistic to act a little offset from the bottom-most point of the gyro wheel case. The Arma Company employs two small oil vessels connected by a tube, the system being somewhat similar, in principle of operation, to the mercury ballistic of the Sperry.

With the compass damped, it would work excellently on land. However, when placed on a moving ship, errors will arise not only due to the ship's course, speed, and latitude, but also due to accelerating forces on all the mechanisms when changing course or speed. To discuss these errors in detail is beyond the scope of this article; but it should be mentioned that when approaching the geographical poles, some of these errors become so great that the gyro-compass is impractical beyond latitudes of 75 to 80 degrees. So far as rolling, pitching, and yawing are concerned, the only detrimental effect is intercardinal rolling on a one wheel Arma; the Sperry is not affected due to its non-pendulousness. Intercardinal rolling on the Arma is eliminated by the use of two wheels—three in the old ones—to bring about what is called "east-west stabilization." All the other errors are taken care of by correcting mechanisms, so that under normal operation both compasses give very accurate readings.

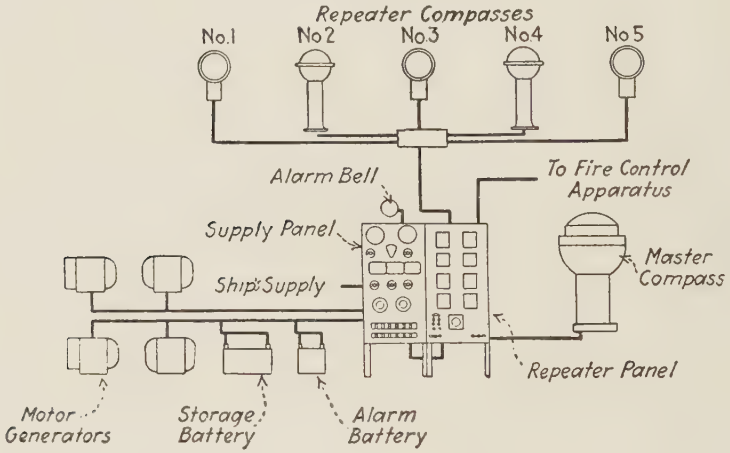
By systems somewhat similar to those used in remote fire control, headings of the master compass are synchronously transmitted to repeaters, which in external appearance look not unlike the magnetic compass and are placed at all points on the ship where at some time or other the knowledge of the ship's heading is a necessity. On the largest naval ships there may be from 15 to 20 of these. The old repeater installations are direct current step by step; the new installations are either selsyn or a modification thereof. In the step by step system the repeaters move by impulses of 10 or 20 minutes; in the selsyn system, the motion is continuous.

The main equipment of a gyro-compass installation consists of the master compass and its supports; batteries in case of failure of ship's supply voltage; one or two small motor-generator sets for supplying other than ship's voltages to the compass; a panel for instruments, switches, rheostats, fuses, and alarm relays;

and a panel for fuses and switches for the repeaters. The large naval ships have two master compasses—one forward and one aft—both placed below protected decks; the smaller ships have one. The new naval installations are about equally divided between Sperry and Arma.

The gyro-compass should be started at least four hours before the ship gets underway. At the time the compass is started the gyro electrician should be advised as to the ship's head (true), in order that the gyro-compass may be started pointing north. While underway, corrections for latitude and speed must be kept

Plate No. 50



mechanically set on the master compass to the nearest degree or knot permitted by the graduations on the latitude and speed correctors. Correction for course is automatically cared for within the compass itself. No one except the gyro electrician should be allowed to touch the master compass.

Before getting underway, the repeaters should be adjusted to read the same as the master compass. While underway, repeaters should be checked with the magnetic and the master compasses every half hour, and the results recorded in a book provided for this purpose. The Officer of the Deck should always receive an immediate report of the results of the compass check, and watch carefully for any indication of possible com-

pass derangements. The record of compass checks may prove invaluable, in a latitude other than that for which the magnetic compass deviation table was made, when there is no opportunity for actual calibration. The series of compass checks in the new latitude may be used to make up a roughly accurate magnetic compass deviation table.

The Azimuth Circle. (Plate **51**).

An azimuth circle is an instrument which is used to take bearings; that is, to note the directions of either terrestrial or celestial bodies. The azimuth circle is a ring which fits snugly over the

Plate No. 51

BEARING CIRCLE AND AZIMUTH CIRCLE.
ON LEFT. ON RIGHT.

top of the compass bowl, but can be moved around the edge easily.

On the upper surface of the ring are secured a pair of sight vanes, a set of observing appliances, a spirit level, and three lugs. The sight vanes consist of a metal leaf, with a vertical slit in the center, and a frame which holds a thin wire vertically and has a movable shiny black leaf outboard of it. One of the vanes is located at each extremity of a diameter of the ring and, since the ring revolves concentrically with the compass bowl, this arrangement causes the line of sight to pass through the vertical axis of the compass at all times. The vane which contains the vertical

wire has a system of prisms and mirrors underneath by which the bearing by compass is brought into the field of view of the observer. By sighting through the vertical slit, and lining it up with the wire and the terrestrial object being observed, a correct compass bearing may be read. Bearings of stars are sometimes taken by sighting across their reflection in the shiny black leaf.

The inner lip of the azimuth circle is graduated clockwise in degrees from 0 to 360, thereby permitting the angular offset of the observed object from the ship's center line, *i.e.*, the relative bearing in degrees of the object, to be read at the lubber's line.

The set of observing appliances consists of a mirror which is capable of being moved on its axis and a box-like apparatus containing mirrors and prisms which reflect a ray of light, entering a vertical slit in the face of the box, on to the compass card.

One of these observing appliances is secured at each end of another diameter of the ring which is at right angles to the line of sight of the vanes, the axis of the mirror being placed at right angles to the diameter. This set of observing appliances utilizes the brightness of the sun to take bearings of it, and these bearings are called azimuths. By means of the mirror a narrow ray of light may be reflected into the slit in the face of the box, and this ray is in turn carried to the compass card as a pencil of light. The azimuth may be read from the compass card at the point where the pencil of light shows on the card.

The spirit level placed outboard of the box-like observing appliance is necessary because the azimuth circle must be in a horizontal plane before a correct bearing is taken. The three lugs facilitate the moving of the ring.

The Bearing Circle (Plate **51**).

The bearing circle is similar to the azimuth circle except that it is not fitted with the set of observing appliances. The sight vane which contains the vertical wire may have an oversized system of prisms and mirrors for greater ease in reading the bearing.

The Pelorus (Plate **52**).

The pelorus is a dumb compass located at any convenient part of the ship, usually in the wings of the bridge, for taking bearings.

FIG. 1. PELORUS.

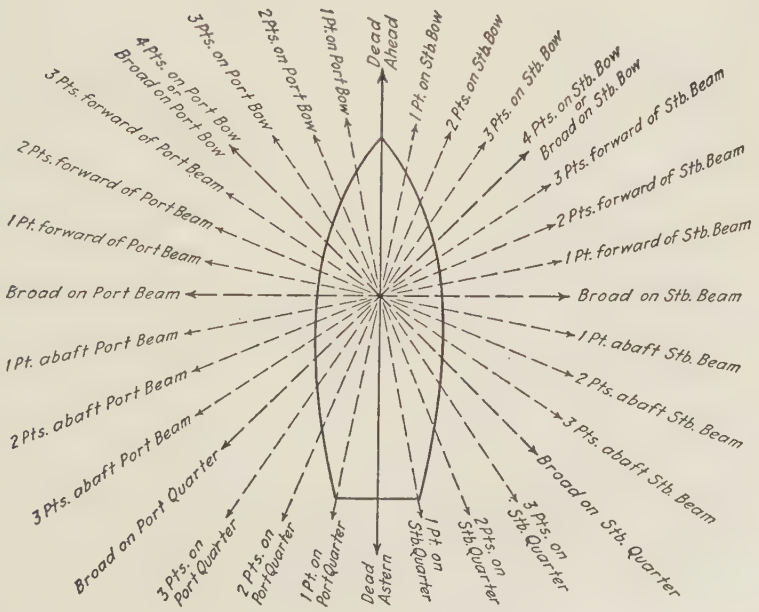

Dead Ahead
1 Pt. on Stb. Bow
2 Pts. on Stb. Bow
3 Pts. on Stb. Bow
4 Pts. on Stb. Bow or Broad on Stb. Bow
3 Pts. forward of Stb. Beam
2 Pts. forward of Stb. Beam
1 Pt. forward of Stb. Beam
Broad on Stb. Beam
1 Pt. abaft Stb. Beam
2 Pts. abaft Stb. Beam
3 Pts. abaft Stb. Beam
Broad on Stb. Quarter
3 Pts. on Stb. Quarter
2 Pts. on Stb. Quarter
1 Pt on Stb. Quarter
Dead Astern
1 Pt. on Port Quarter
2 Pts. on Port Quarter
3 Pts. on Port Quarter
Broad on Port Quarter
3 Pts. abaft Port Beam
2 Pts. abaft Port Beam
1 Pt. abaft Port Beam
Broad on Port Beam
1 Pt. forward of Port Beam
2 Pts. forward of Port Beam
3 Pts. forward of Port Beam
4 Pts. on Port Bow or Broad on Port Bow
3 Pts. on Port Bow
2 Pts. on Port Bow
1 Pt. on Port Bow

FIG. 2. RELATIVE BEARINGS.

The dumb compass dial is a glass plate marked like a compass card, which can be turned inside of the fixed rim carrying the zero mark. The sighting vanes are set at any desired angle with respect to the zero mark, and turn independently of both the glass compass card and the zero mark. In this form of instrument the point of the glass compass card corresponding with the compass course of the ship is made to coincide with the zero mark, so that the compass bearing of an object sighted upon is read off directly, provided that the ship is exactly on her course at the instant of making the observation. If it is necessary to make the observation while the ship is not on the course for which the pelorus is set, the difference must be noted and applied to the bearing observed.

Suppose the pelorus is set for course 270 degrees, and a bearing of 315 degrees taken when the ship is actually heading to the left of this course, on 265 degrees. The bearing given by the pelorus must be corrected by 5 degrees applied to the left, like westerly deviation, and the corrected bearing is 310 degrees. If, the pelorus being set as before for 270 degrees, the ship actually heads to the right of this course, on 275 degrees—the correction must be applied to the right, like easterly deviation, and the corrected bearing becomes 320 degrees.

The accuracy of the adjustment of the zero mark in the keel-line of the ship may be determined by setting the glass compass card to the compass course and taking simultaneous bearings with the compass and pelorus of a distant object. If an error is found to exist, it may be noted and applied as a permanent correction to all observations taken with that instrument; or the adjustment may be corrected.

The pelorus stand may take any one of several forms, but is usually a simple hollow, cylindrical column, with access to a switch through a door in the side, by which the intensity of light is varied for illuminating the compass card from below.

A gyro-compass repeater fitted with a bearing circle may be shipped in the pelorus stand, when by common usage it is incorrectly referred to as a pelorus. The sighting vanes of the bearing circle are directed at the desired object, and the gyro-compass bearing read directly, regardless of how the ship is heading.

Bearings.

The bearing or direction of an object from the ship may be stated in one of the following ways:

(1) **Compass bearing.** Bearings taken with any compass are compass bearings. Record of such a bearing should include identification of compass used.

(2) **True bearing.** Bearings of an object taken with a compass which is pointing true north will be true bearings. Bearings taken with a gyro-compass are true bearings, provided the compass has no error. Bearings taken with a magnetic compass must be corrected for the compass error (variation and deviation) to correct them to true bearings.

(3) **Relative bearing.** The bearing of an object with respect to the fore and aft line of the ship is a relative bearing.

(*a*) In degrees. The relative bearing of an object may be expressed in degrees to the right or left of the ship's head through 180 degrees, or it may be expressed in degrees from the ship's head around to the right through 360 degrees.

(*b*) By "points." There are 32 points in a circle. One point equals 11¼ degrees. The method of naming relative bearings by points is shown in Fig. 2, Plate **52.** The principal use of relative bearings by points is for the reporting by lookouts of objects sighted.

The Radio Direction-Finder.

Practical use of the radio direction-finder was first made during the World War to locate enemy radio stations. It has since found extensive use, particularly in marine navigation.

The radio direction-finder is a valuable instrument developed for receiving radio signals and at the same time determining the line of direction taken by the traveling radio waves—in other words determining the bearing of the origin of the received radio waves. Its operation depends on the directional characteristics of the loop antenna, and it consists essentially of a coil of wire (loop antenna) for receiving the signals, the wire being wound around a rectangular form and the ends of the coil connected with suitable apparatus for making the signals audible through head-phones, or for indicating signal intensity by visual means.

The coil is mounted on a vertical axis above a horizontal circle graduated in degrees, and a pointer connected with the coil indicates the angle at which the coil stands with reference to the zero line of the circle. On land the horizontal graduated circle has its zero line fixed at true north; on board ship the zero line is fixed in the fore and aft line of the ship giving bearings relative to the ship's head, or is replaced by a gyro-compass repeater and automatic deviation compensating device giving true bearings. Radio signals impinging upon the receiving coil become audible in the head-phones of the operator, the intensity of the sound varying with the position of the coil relative to the line of direction of the incoming radio waves. If the plane of the coil is at right angles to this direction minimum sound is heard, if the plane of the coil is parallel to the line of direction maximum sound is heard. It is found in practice that more accurate determination of direction is possible by the disappearance of sound or minimum intensity than by its maximum intensity; and the pointer is accordingly placed to point at right angles to the plane of the coil.

The "bilateral" characteristics of the loop, the properties that determine the line of direction of the observed signal, may be accounted for as follows: When the plane of the coil is at right angles to the line along which the wave is approaching the wave front is parallel with the plane of the coil. Thus the wave strikes both sides of the loop at the same instant and induces e.m.f.'s of identical phase in both sides of the loop which cancel out, nullifying any tendency for current to flow (minimum sound). When the wave is approaching along a line of travel parallel with the loop the wave front strikes one side of the loop a fraction of a second sooner than it strikes the other side, and the current in the side of the loop nearest the source starts to flow before the current in the side farthest from the source has time to build up to nullify it (maximum sound).

The "unilateral" or "unidirectional" characteristics of the loop, the properties that determine from which quadrant a signal is coming, may be obtained by utilizing the maximum sound position of the loop as follows: A vertical wire antenna (balance antenna) is coupled to the loop antenna in such a manner that by mixing their energies in proper phase relation the sound intensity in the head-phones is greater when one side of the loop

points in one direction than when it points in the opposite. Thus an auxiliary pointer fastened parallel to the plane of the loop is so directed that the signal is stronger when the arrow points toward the source than when it points away in the opposite direction.

In practical operation, it is found that maximum signal when using the loop and the vertical antenna together is considerably stronger over a fairly wide arc in one-half of the circle of rotation than it is in the other half. This tells the observer that the source of signal lies in the half of the circle in which the signal is stronger, and the auxiliary pointer thus indicates the general direction of the source. It is then only necessary to shift over to the loop alone and utilizing its bilateral characteristics determine by minimum intensity of sound the accurate single direction, or the bearing of the signal source.

There are various ways of applying the radio direction-finder to navigational purposes. Installed on board ship, it may be used for taking bearings on any source of signals, as another ship or a radio beacon. The bearing, *corrected for the deviation of the radio direction-finder for that particular bearing relative to the ship's head*, may then be used as is any other navigational bearing. Or, the radio direction-finder may be installed at a shore station so situated as to give any ship requesting same its true bearing from that station. And when several such stations are connected together in a group by land wire, and centrally controlled, they are able to give a requesting ship its exact geographical position.

H. O. Publication No. 205, "Radio Aids to Navigation," gives all necessary information concerning radio-beacons established on most of the important lighthouses and lightships of the world, and the radio direction-finder stations maintained at the entrances to the principal harbors. The latest issue of H. O. 205 should always be consulted for the details of requesting bearings, for exact geographical location of stations or beacons from which bearings are to be plotted, and for information concerning accuracy of bearings and any corrections to be applied.

Too much emphasis cannot be placed on the importance of studying carefully the several pages of information concerning radio bearings, contained in "Radio Aids to Navigation," before either the novice or the inexperienced person attempts to use

them. A clear understanding of their possible sources of error is essential.

The Measurement of Speed.

The speed of a ship may be measured in any one of the following ways:

(1) By a log, of which there are many types.

(2) By the revolutions of the propellers.

(3) By running over a measured course or between bearings of charted points on shore.

Whatever method is used, due allowance must be made for current and wind, and the distinction recognized between speed through the water and speed over the ground.

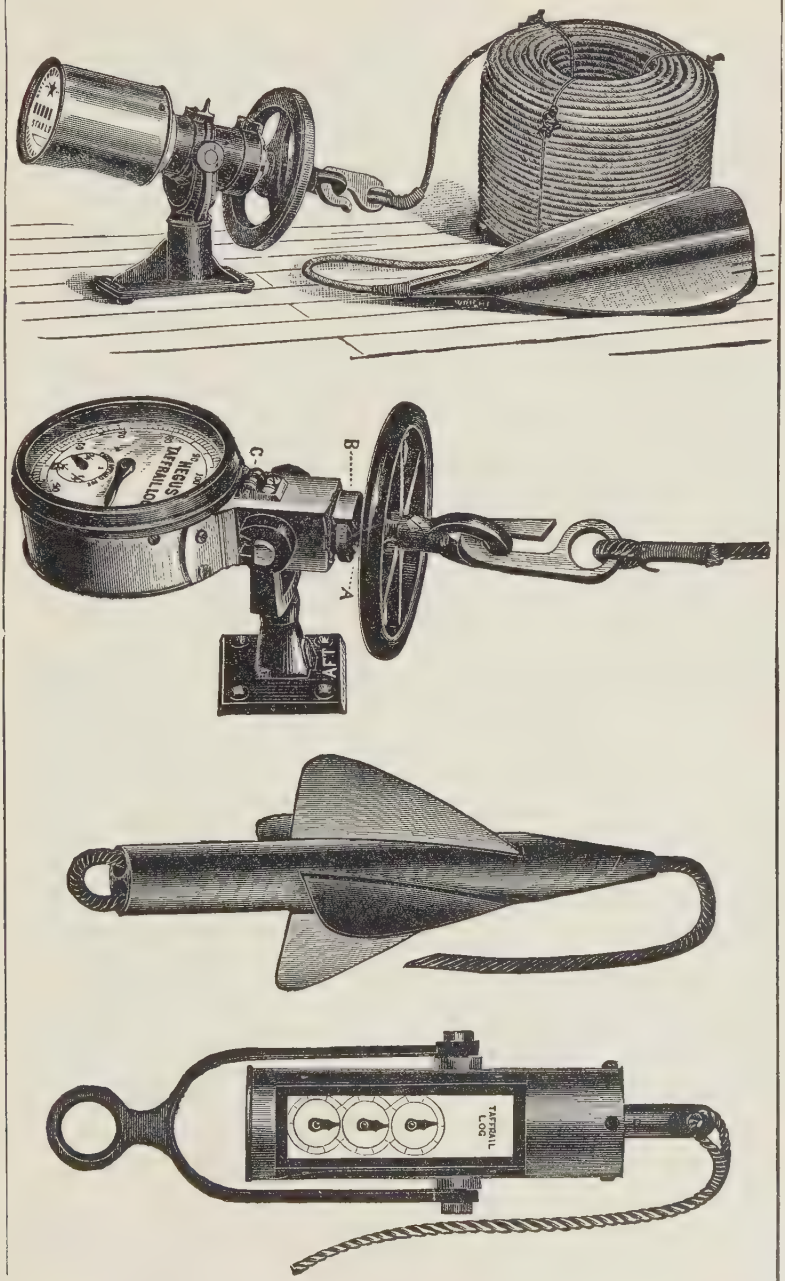
The Chip Log.

The chip is a thin wooden quadrant of about six inches radius, loaded on the circular edge with sufficient lead to make it float upright in the water. From its three corners a towing bridle is attached to a log line of about one hundred and fifty fathoms in length. The chip is thrown over the stern, and the speed is calculated by measuring the amount of time it takes for a set amount of line to run out. This type of log is mainly of historic interest, as it is now practically obsolete.

The Taffrail Log (Plate **53**).

Taffrail logs are of several types, but all act on the same principle. They consist of a registering device, a towline, and a rotator. The registering device is secured conveniently near the stern, *i.e.*, on the taffrail. The rotator, in principle like the propeller of a ship, has its vanes so constructed and attached that the number of turns which it makes is proportionate to the speed at which it is being towed through the water. The rotator transmits its motion by a proper length of towline to the registering device. The dials of the registering device record distance and not speed, therefore to find speed the length of time between successive readings must be noted.

Logs depending on a towed rotator often give false readings due to the fact that seaweed or other obstructions slow down or stop the rotator for a time.



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PATENT LOGS.

The Harpoon Log.

This log is similar to the taffrail log, except the registering mechanism is towed astern with the rotator, and must be hauled in for reading.

The Ground Log.

When the water is rather shallow and speed low, use is sometimes made of the ground log, consisting of a moderately heavy lead on the end of a log line. The lead is thrown over and allowed to sink to the bottom, after which a known amount of line is paid out and the time noted, exactly as in the case of the chip log, care being taken not to drag the lead. This method not only gives the speed over the ground, but also shows the direction of the set. A ground log would be of special value in confined waters, in a fog, where the force and direction of the current might be of vital importance and the speed necessarily low.

The Pitometer Log (Plate **54**).

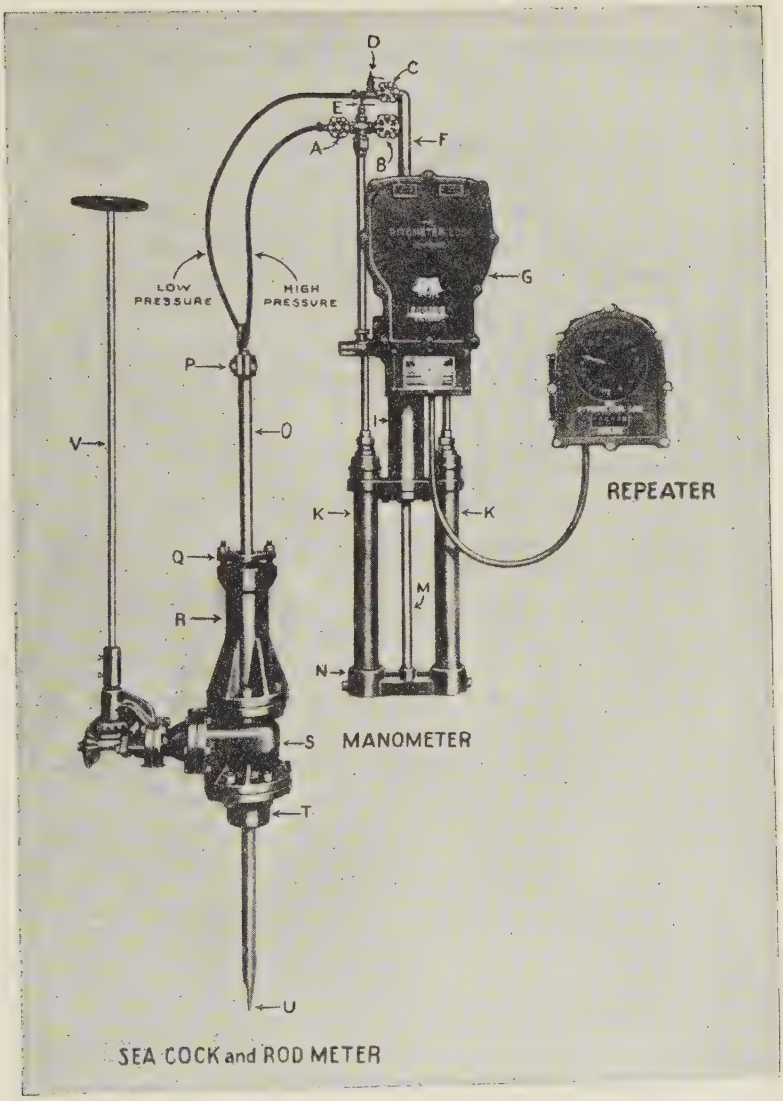
The Pitometer Log is a navigating instrument (manufactured by the Pitometer Log Corporation) for accurately indicating the speed of a ship through the water and also for registering the distance traveled. Type MS-25, for battleships, will be described.

The speed element is based on the action of water pressures from a Pitot tube causing a deflection of mercury in a U tube or manometer, which moves a dial graduated in knots.

The distance traveled is totalized by means of a mechanical integrator and cam attached to the speed dial. Both speed and distance readings are reproduced electrically in different parts of the ship by means of repeaters.

The Pitot tube or rod meter contains two small tubes, one terminating in a dynamic orifice which points forward, the other in a static orifice opening on both sides of the flat tip. The rod meter is supported by a sea cock, having an extension with a watertight gland, and projects about three feet below the bottom so that it reaches water unaffected by the movement of the vessel at any speed.

When the ship is in motion with the rod meter in its extended position, the dynamic orifice receives a pressure which is greater



PITOMETER LOG.

than the comparatively constant pressure on the static orifice. The difference between these two pressures is a function of speed and is independent of rolling and pitching or variations in ship's draft.

The water pressures from the rod meter are transmitted to the mercury manometer which is so calibrated as to indicate the speed of the vessel in knots.

The dynamic pressure, due to the velocity of the ship, is connected to the side tubes which act together as one leg of the manometer. The static head is transmitted to the top of the large tube or float chamber.

By means of the differential areas in the manometer, the mercury is made to rise about twelve inches in the float chamber, while falling about eighteen inches in the side tubes at the maximum speed of 25 knots. The manometer is supported in gymbals so that the movements of the ship will not affect its accuracy.

A float, supporting a rack, is located in the float chamber and rises and falls with the mercury. The rack drives a gear, the shaft of which extends out of the gear chamber and is connected by means of an adjustable coupling to the main drive shaft of the transmitter case which carries the master speed dial.

The mercury manometer is so designed that the master dial revolves 338 degrees for the maximum speed of 25 knots. Since the rise of the mercury float controls the movement of the master dial this rotation is directly proportional to the mercury deflection in the manometer which in turn bears a square root relation to the speed of the ship. The mercury deflection corresponding to each knot is determined by direct hydraulic laboratory calibration and is checked over a measured mile by the ship at all speeds.

Distance is registered by means of an electrically operated mechanical integrator. A cam on the main shaft is so formed that it limits the angle through which an integrating arm swings, in direct proportion to the speed. A pawl on this arm drives the integrating wheel and its counter at fixed time intervals by means of a small motor controlled by a self-winding clock with special contacts.

Since the integrating wheel turns in proportion to the speed, the time interval is so fixed that the master distance register will indicate distance traveled. This register is a standard counter and carries a star wheel on its shaft which closes a pair of con-

tacts every tenth of a mile, thus operating the distance repeaters which are magnetic counters.

The master speed reading is repeated by means of a number of repeater dials with pointers mounted on the shafts of selsyn repeating motors, all of which are operated from the selsyn transmitter, which is geared directly to the master dial shaft.

Revolutions of the Propellers.

The revolutions of the propellers afford a very convenient indication of the speed of the ship but are subject to certain corrections, nearly all of which are matters of estimate rather than of exact determination. Revolutions are calibrated with reference to speed under standard conditions: draft and trim normal, the bottom clean, and weather moderate. Under these conditions runs are made at different speeds over a measured course. The average of several runs at each speed in both directions is used to eliminate the effect of wind and current. The averages for the different speeds are then plotted to obtain a calibration curve, and from this curve a table of revolutions required for any speed is made up for the given conditions of the calibration runs. Over a period of time data may be collected for varying conditions of draft, trim and foulness of bottom.

If the length of time out of dock were an accurate measure of the degree of fouling, the condition of the bottom would always be approximately known, but this is not always the case and this element in the problem must be estimated from what is known of the facts. The fouling will be greater in the tropics than in temperate waters, greater in salt water than in fresh, greater for time spent at anchor than for time underway. A foul bottom tends to clean itself in steaming at high speed. A ship badly fouled at sea, lying for a considerable time in fresh water can check the growth of barnacles; the live organisms dying within three days. However, the shells do not drop off, but remain on the ship's bottom, reducing speed. A ship lying for a long time in fresh water may take on grass.

As experience is gained with any particular type of ship, very close approximation can be made of the correct revolutions to be used for the desired speed. There are numerous types of mechanical and electrical revolution indicators installed, and descrip-

tive information will always be available for the type found on any given ship.

Sounding.

Sounding is the act of determining the depth of the water. Soundings may be taken with the lead, sounding machine, or sonic depth finder.

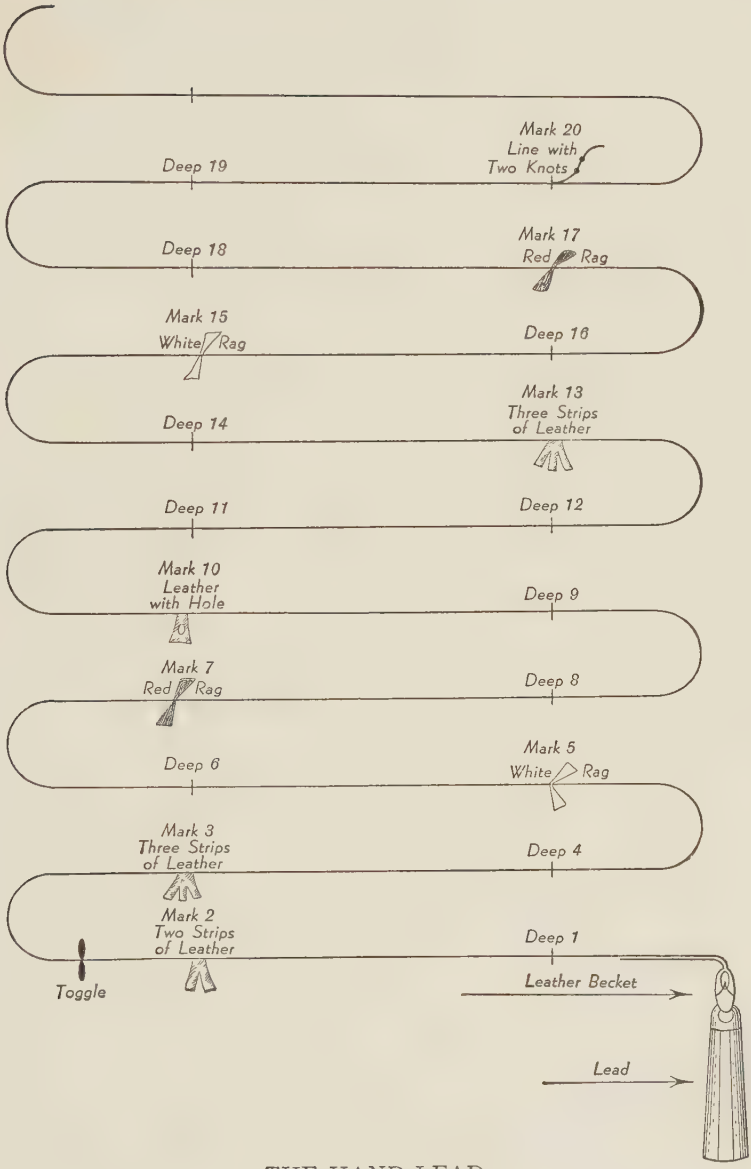
The Hand Lead (Plate **55**).

Soundings, to ascertain the depth of water on entering or leaving port, or in any case where there is supposed to be less than 15 fathoms of water, are taken by the hand lead. Soundings are taken while the vessel has headway on; the leadsman heaves the lead forward and gets the depth as the vessel passes, when the line is nearly perpendicular. A good leadsman in sufficiently high chains should get accurate soundings in 7 fathoms at 12 knots, 10 fathoms at 10 knots, and 15 fathoms at 7 knots; in depths greater than this, the speed must be reduced or other means used.

The lead line is made up of about 25 fathoms of three-quarter inch braided cotton twine marked in fathoms, with a wooden handle or toggle lashed into the line about two fathoms from the lead. Braided cotton twine best meets the requirement that the lead line should neither stretch nor shrink excessively as it is alternately wet and dried. The lead is securely attached to the line, and weighs either seven or fourteen pounds.

Before marking, the line is well soaked, and then measured carefully and marked as follows from the lead:

2 fathoms ..... 2 strips of leather.
3 fathoms ..... 3 strips of leather.
5 fathoms ..... white rag.
7 fathoms ..... red rag.
10 fathoms ..... piece of leather with hole in it.
13 fathoms ..... as at 3.
15 fathoms ..... as at 5.
17 fathoms ..... as at 7.
20 fathoms ..... 2 knots.
25 fathoms ..... 1 knot.
30 fathoms ..... 3 knots.
35 fathoms ..... 1 knot.



THE HAND LEAD.

These are known as "marks," and the numbers omitted are the "deeps." Soundings should be reported loud enough to reach the bridge, and in the exact phraseology indicated here:

Report:	*Depth Corresponding With:*
"By the mark five!"	Five-fathom mark.
"And a quarter five!"	Greater than, but not one-half fathom greater than five-fathom mark.
"And a half five!"	One-half fathom greater than five-fathom mark.
"Quarter less five!"	Less than, but not one-half fathom less than five-fathom mark.
"By the deep four!"	Estimated deep between the marks.
"No bottom at fifteen!"	No bottom at fifteen-fathom mark.

At night the leadsman should know the distance from his hand to the water's edge, and at each cast should subtract this distance from the mark in his hand for the true sounding. Or a special lead line may be made up, on which the distance from the water's edge to the leadsman's waist is laid off on the line before beginning to measure for the marks, then the actual depth is indicated by the mark in the leadsman's hand.

Lead lines for use in accurate sounding work, such as hydrographic surveys, are usually marked in feet.

The Deep-Sea Lead.

The deep-sea lead, pronounced "dipsey," is briefly described here mainly for its historical interest, as its purpose is now better served by the sounding machine and sonic depth finder. The lead weighs from 30 to 100 pounds, and is attached to a line correspondingly heavy, marked every five fathoms—1 knot at 5, 15, 25, 35, etc., fathoms; 2 knots at 20, 3 knots at 30, 4 knots at 40, etc. The bottom of the lead is hollowed out, and this hollow is filled with tallow before dropping. By thus "arming the lead" a sample of the bottom is brought up for comparison with the kind of bottom indicated on the chart. Knowing the depth and kind of bottom aids a navigator in quite accurately fixing the ship's position.

In obtaining a sounding, the lead is taken to the forecastle and the line passed aft on the weather side, outboard of every-

thing. Men are stationed at short intervals along the rail, each with a small coil of the line in his hand. The engines are stopped, and when the ship has nearly lost her way, the forecastle boatswain's mate sings out, "Watch-ho, watch," and heaves the lead over the side, well clear. Each man in succession holds onto the line until he feels the weight of the lead, when he sings out, "Watch-ho, watch," and lets go the bight. The man who obtains bottom while the line is in his hand reads it off as he would a hand lead line. The line is then carried to a small snatch block, hauled in, and the character of the bottom recorded.

The Drift Lead.

The drift lead should be put over the side when there is any possibility of the ship dragging anchor, whether due to a swift tideway, bad weather, or the poor condition of the bottom for holding an anchor. A drift lead consists of a heavy lead, 30 to 50 pounds, secured to the end of a line. Enough hand leads to make up the necessary weight may be used if a heavy lead is not available. The drift lead line is not marked.

The best location for the drift lead is near the bow where it will be less affected by swinging and yawing. After the lead has been placed on the bottom, close to the side of the ship, the line should be secured to the ship at a point directly over the lead, but with a fathom or so of slack in the line, then a tautening of the line will give a visible indication that the ship may be dragging. The drift lead should be taken up before a swing, and replaced immediately after the swing. A ship is particularly liable to drag as the current starts to run after a swing, because the swing may loosen the anchor and the growing current then "breaks it out."

When there is any likelihood of dragging, the riding chain should also be observed for the characteristic jumps caused by a dragging anchor, and in addition a "range" should be watched. A range should always be checked from the same point on the ship, and consists of any two well-defined objects on shore that may be lined up. With two ranges, one near either beam, the difference between yawing or swinging and actual dragging is easily distinguished. This is not necessarily true of the drift lead, and the drift lead is then most useful as an additional pre-

caution. A "fix" obtained by compass bearings of terrestrial objects may be used in the same manner as "ranges."

The Sounding Machine (Plate **56**).

The original sounding machine was invented years ago by the great Scotch scientist, Lord Kelvin (then Sir William Thompson), and all later machines are based upon the principle which he first applied: The principle of determining the depth of water by the pressure of the water at the depth in question, this pressure being registered on the inside of a glass tube open at one end and closed at the other. The tube, with closed end up, is lowered in the water, and the pressure of the water acting upon the air in the tube compresses the air and forces the water up into the tube to a height which depends upon the pressure and therefore upon the depth.

There are two types of tubes in general use:

(1) "Chemically-coated" tubes are coated on the inside with chloride of silver, a substance which changes color on contact with salt water.

(2) "Ground-glass" tubes are ground on the inside so that they show clear glass when wet, this being a peculiarity of ground glass.

The interior of the tube, on account of its coating or finish, retains a line of sharp demarcation at the point to which the water rose, and this mark indicates the depth, when the tube is fitted into its proper measuring scale. Care should be taken to keep the closed end of the tube upward after sounding, for, if capsized, water may run into the upper end and spoil the record. The advantage of the ground-glass tube is that it can be used an indefinite number of times if thoroughly dried after each cast, while the chemically-coated tube may not be used again unless it is certain that the depth of water is greater than that which the tube has previously indicated.

The sounding machine can be used to take soundings without stopping or slowing the ship. The several types of sounding machines all consist essentially of a stand for carrying a drum, on which is wound several hundred fathoms of galvanized piano wire. The drum is controlled by a friction brake regulating the rate at which the wire runs out. To the end of the wire is at-

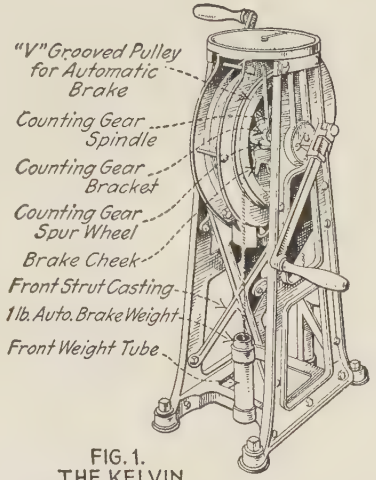


FIG. 1.
THE KELVIN SOUNDING MACHINE
(Kelvin and Wilfred O. White, Boston)

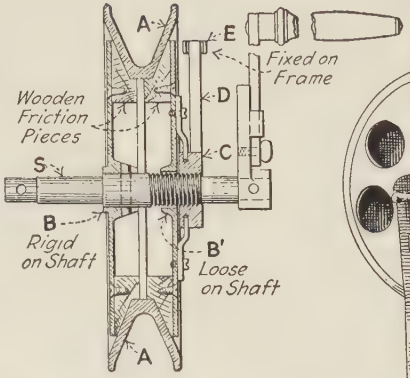


FIG. 2.
DETAILS OF KELVIN MACHINE

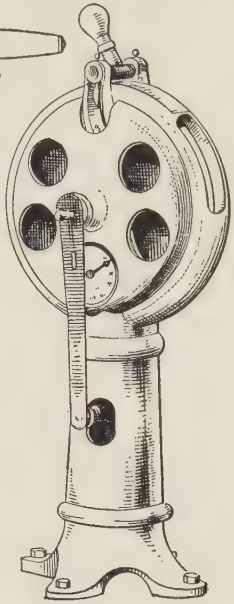


FIG. 3.
THE TANNER-BLISH MACHINE

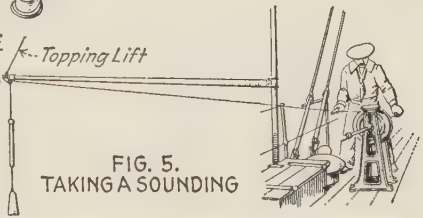


FIG. 5.
TAKING A SOUNDING

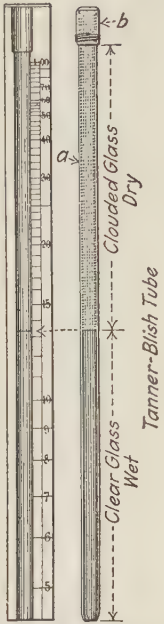


FIG. 4. TUBE AND SCALE AFTER SOUNDING IN 13½ FATHOMS

tached a brass cylinder which carries and protects the glass tube. The tube is carefully fitted into the cylinder closed end up. Beyond the cylinder and connected to it by a short length of plaited line is a heavy sinker or lead, insuring rapid sinking. The lead has a cavity in its lower end armed with tallow in order to bring up a sample of the bottom. The wire is led clear of the ship's side by a sounding boom installed adjacent to the sounding machine. A dial on the machine indicates the amount of wire out, and must be set at zero before a sounding is taken. The drum is turned by means of two handles when operated by hand, or it may be turned by an electric motor.

In taking a sounding the brake is released and the wire runs out, trailing far astern when the ship is moving at high speed. If the lead finds bottom, the wire slacks suddenly, and the brake must be applied immediately to prevent kinking of the wire. As a further insurance against kinking, a brass finger-pin is used to keep a light pressure on the wire as it runs out, and is pressed down quickly upon the wire as it slacks.

The length of wire that has run out would be a measure of the depth if the speed of the ship and the friction of the brake were constant. An experienced operator using the brake uniformly can make a fair estimate of the depth without waiting to reel in and read the tube. Such an estimate may often give an instant warning of danger. In some machines an effort has been made to provide for constant friction on the brake, and a table issued with the machine gives the depth for different speeds corresponding to the length of wire out as indicated by the dial. This is valuable, but not sufficiently reliable to replace a careful reading of the tube as soon as it is available.

The Fathometer[1]

The Submarine Signal Company presents in the fathometer a distinct advance in the means for determining the depth of water under a ship, whether it is at rest or steaming at its maximum speed.

Prior to the invention of the fathometer, the usual method for determining the depth of water beneath the ship, *i.e.*, of taking soundings, was by the use of a line to which apparatus was at-

[1] Information furnished by the Submarine Signal Company.

tached. This method is comparatively slow inasmuch as the reported depth is not that of the water under the moving ship but rather the depth a mile or more back on the course. In the fathometer is incorporated the principle of "Echo Depth Sounding" which enables soundings to be made, with great accuracy and many times a minute, of the depth of water under the ship at the instant a sounding is made. This is of prime importance to those charged with safe navigation.

The process of "Echo Depth Finding" is illustrated in Plate **57.** Briefly, it consists of producing, with a submarine oscillator located in the bottom of a ship, a sound of such intensity as will cause it to travel to the ocean floor and be reflected back. This returning sound or "echo" is caught by a sensitive receiver (hydrophone) which is also located on the ship's bottom. The difference between the time of producing the sound and receiving the "echo" from the ocean depths is so translated by the fathometer indicator that it appears on the dial as a flash of red light opposite a numeral corresponding to the depth in fathoms.

The fathometer is put into operation by turning the starting switch. Automatic sounding begins at once, as evidenced on the dial by flashes of light opposite the correct depths. Depth will continue to be registered on the fathometer dial as long as desired. Sudden changes in depth are immediately indicated in the same manner as are gradual changes.

Fathometer installations are designed to meet the requirements of several classes of vessels. The Submarine Signal Fathometer Type 480, herewith described, has been designed for vessels which require depth soundings of from 3 to 130 fathoms under the keel.

The installation of Fathometer Type 480 includes five units:

1. Fathometer Indicator (Type 480)
2. Amplifier
3. Sound Producer (Oscillator)
4. "Echo" Receiver (Hydrophones)
5. Receiver Tank

The Fathometer Indicator is located in the chart house or wheel house in order that the soundings may be continuously observed by the Navigator. The numerals on the fathometer

ECHO DEPTH SOUNDING.

dial (3 to 130 fathoms) are of such size that the readings are legible and accurately read at some distance. The red flashes on the dial occur at the rate of about 24 per minute and each flash indicates the depth at the instant.

The Amplifier, including the dry cells required for its operation, is installed in a compact case located near the fathometer indicator.

Plate No. 58

TYPE 480 FATHOMETER INDICATOR.

The Sound Producer (Submarine Oscillator) comprises an electromagnet, a plunger, and a steel diaphragm assembled in a watertight case. This sound producer is mounted in a forward compartment of the ship in a water-filled tank which is so designed that one side of the tank is formed by the ship's skin.

The "Echo Receiver" consists of a pair of hydrophones, housed in a small cast iron tank which is filled with water after it is

mounted between the ribs of the ship. One of the plates of the vessel forms one side of the tank.

The maintenance of the fathometer installation is confined practically to the renewal of vacuum tubes and dry cells in the amplifier from time to time. All parts are rugged and so designed as to give continuous service with ordinary care, and are conveniently and permanently located so as to be out of the way of accidental injury.

The Fathometer Recorder is designed for use in conjunction with the fathometer indicator to record on a paper chart the depth of water beneath the vessel as indicated visually by the fathometer indicator. The recorder is installed to the left-hand side of and near the indicator. The recorder is connected mechanically to the indicator by means of a flexible shaft which serves to actuate the entire recorder mechanism and insures synchronization of the indicated and recorded depths. The record consists of a series of small lines about three-sixteenths of an inch or less in length, which overlap as the paper is fed lengthwise through the recorder. These marks follow one another at frequent intervals forming a solid line, the left-hand edge of which, looking at the chart as it is placed in the machine, indicates the depth.

Submarine Signals.

This is a system for transmitting sound signals through the water, and receiving them by special instruments on shipboard, the receiving arrangement being of such a nature as to admit of determining, at least approximately, the direction from which the sound is received. It is in fact a system of "direction finding" applied to sound, resembling somewhat, in principle and in operation, the radio direction-finder as applied to radio waves.

The Submarine Bell.

A bell submerged in the sea and so located as to mark a danger point or a position of importance to navigation is sounded automatically at regular intervals with a characteristic signal which fixes its identity. The sound of the bell is transmitted through water, and experience has demonstrated that sound signals transmitted through water are superior in range and reliability to those transmitted through air. With special apparatus

for receiving the underwater sound signals, magnifying, and transmitting them to the ear, the range of audibility is from 10 to 30 miles, depending upon conditions; *i.e.*, upon the speed of the ship and the relative bearing of the bell. High speed is unfavorable, to some extent, doubtless because the wash of the

Plate No. 59

FATHOMETER RECORDER.

water along the ship's side interferes with the sound. The relative bearing of the bell determines the angle at which the underwater sound waves reach the receiver with the result that a signal on the beam can be heard farther than one which is forward or abaft the beam.

The submarine bell does more than announce with certainty the proximity of the danger point which it marks. It fixes the direction of the danger within narrow limits; and in those waters —common enough on irregular coasts—where the zones of two or more signals intersect, the position of the ship may be plotted with considerable accuracy by the crossing of the lines of bearing, exactly as in the case of visible bearings, though not with the same degree of accuracy.

The Fessenden Lightvessel Oscillator.

The oscillator may replace the bell, and consists of a powerful electromagnet and diaphragm so arranged that when the electromagnet is energized by an alternating current, the diaphragm is caused to move to and fro at a definitely established frequency, thus producing a very powerful submarine sound. The sound is so intense that it can be heard easily at three times the range of the submarine bell.

The reason why the oscillator signals are of so much greater range than those of the bell is that the oscillator signals are undamped, while those of the bell are highly damped. In other words, the oscillator signals remain at maximum intensity throughout the time of their duration, while those of the bell are at maximum intensity only at the instant that the striker hits the bell. In addition to greater range, the oscillator provides a signal of easier recognition than does the bell.

S-29 Submarine Signal Company's Receiving Apparatus.

The purpose of the receiving apparatus is to provide means whereby the direction of the source of a sound in water originating at some distant point can be readily determined by observers on shipboard. This is accomplished by mounting two tanks (Plate **60**) on the vessel's plates, inside the vessel, one on each side toward the bow. The vessel's side plating forms one side of the tank.

These tanks are filled with water and microphones are submerged in the water within the tanks. Each microphone is so arranged that it can be connected, by means of a switch, with telephone receivers placed at the ears of a listener. When the

sound waves from a distant source reach a vessel equipped with this receiving apparatus, the sound waves agitate the sides of the vessel, and through the medium of the water in the tanks actuate the microphones, thus varying the electric current and so

Plate No. 60

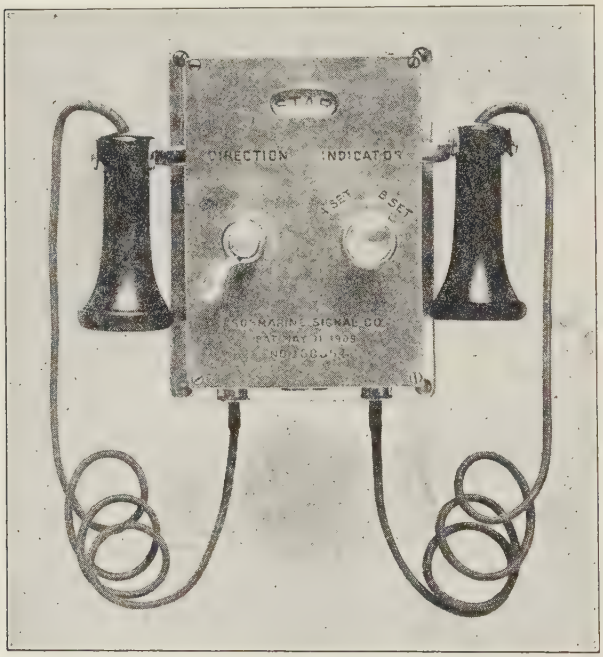
RECEIVING APPARATUS (HYDROPHONES) IN TANK ATTACHED TO SIDE OF SHIP.

producing similar sounds in the telephone receivers held at the ears of the observer in the listening station, which is usually located in the pilot house. The sounds heard in the telephone receivers will be loudest when they are connected with the microphone on the side of the vessel nearest to the source of sound.

By turning the vessel until the sounds are the same from microphones on both sides of the vessel, the direction of the source of sound can be ascertained, for the reason that when the sounds are equal the vessel must be pointing directly toward the source of sound.

Four microphones are used in each installation, two being suspended in the port tank and two in the starboard tank. One

Plate No. 61



INDICATOR BOX.

microphone in the port tank and one in the starboard tank form a pair and are carefully matched so as to be substantially equal in volume and sensitiveness. One pair is called the "A Set" and the other pair the "B Set." Each microphone is numbered; the odd numbers are suspended in the port tank and the even numbers in the starboard tank. Should a microphone fail and have to be replaced, the other microphone of the pair should also be

removed. The pair, of which one was defective, should then be replaced by a new pair of matched instruments.

All four microphones are connected with the indicator box, the circuits of which are so arranged that the two telephone receivers may be used with one or the other set of microphones in ascertaining direction. By this arrangement there is provided a substantially duplicate installation so that the observations on one set of microphones can be compared with similar observations on the other set. It is of importance to note that at any one time both telephone receivers are connected with but one microphone on one side of the ship only.

The indicator box (Plate **61**) is a substantial polished brass composition case containing the connections and switches required in the operation of the system. Hooks are arranged on each side upon which the telephone receivers, which are connected in series with the microphones and a battery, can be hung when the system is not being used. The hooks control switches which open the electrical circuit when they are depressed by the weight of the receivers. At the left of the face of the box is a handle by means of which the telephone receivers can be connected with a microphone in either the port or the starboard tank. The connections are indicated by a semaphore appearing at a window near the top of the indicator box. At the right of the face of the box is a knob controlling a switch which permits the microphones of either set "A" or set "B" to be thrown into circuit.

Distance Finding by Synchronous Signaling.

Distance Finding by Synchronous Signaling is based upon the fact that radio waves and underwater sound waves travel with greatly different speeds. Radio waves travel with a velocity equal to that of light and therefore the time required for them to travel over a distance of twenty or thirty miles is negligible. Underwater sound waves, on the other hand, travel with a velocity of only about 4800 feet a second and therefore a measurable time lapses while the sound waves are traveling over the same distance. If, therefore, a radio signal is created simultaneously with the underwater sound signal emitted by the submarine oscillator and the time lapsing between the arrivals of

RADIO SIGNALS AND SUBMARINE SIGNALS SENT OUT SIMULTANEOUSLY FROM LIGHTSHIP.

TIME INTERVAL BETWEEN RECEPTION OF RADIO SIGNALS AND SUBMARINE SIGNALS ON LINER INDICATES DISTANCE TO LIGHTSHIP.

the radio and submarine signals is measured, definite knowledge is obtained of the ship's distance from the lightvessel at which the synchronized radio and submarine signals are produced.

Consequently, as illustrated in Plate **62**, the determination of the distance from a lightvessel emitting synchronized radio and submarine oscillator signals is only a matter of measuring the difference between the times of arrival of the two kinds of signals.

To make distance finding observations available on ships already equipped with submarine signal receiving equipment no new apparatus is required other than a circuit arrangement whereby the same observer is enabled to hear both the radio and the synchronized submarine signals and a watch wherewith to measure the time interval between the arrival of the signals at the receiving ship. A stop watch or a special form of stop clock having a dial graduated in miles will serve to indicate the distance between the ship and the source of the synchronized signals. This distance combined with an approximate bearing of the submarine signal obtained by use of the receiving apparatus, or with a radio direction-finder bearing of the radio signal, may fix a ship's position quite accurately when no other means is available.

CHAPTER VII.

BOATS.

There are many types of boats in use, each one having been developed to meet conditions peculiar to its purpose or place of origin and from which the type often takes its name. Most of these types are represented by those in service in the U. S. Navy, the U. S. Coast Guard and in the Merchant Service. The principles of construction and handling being fundamentally the same for all types, only the above-mentioned boats will be described.

Boats designed to be carried on shipboard are subject to many conditions which define their characteristics within narrow limits, especially as regards their size and weight. These limits are determined, first of all, by the specific purposes for which the boats are to be used, and next by the facilities available for stowing and handling them.

The Coast Guard's shore based boats are not hampered by these limitations and are built to meet only the rigorous conditions of sea, surf and weather to be encountered in their specialized duty.

Construction of Boats (Plates **63, 64**).

Boats are made of both wood and metal and by a number of systems. In wood, three general types of construction are common:

Carvel, Clinker and Diagonal Wooden Boats.

In *Carvel* building (Plate **63**, Fig. 1), the planks lie alongside each other without overlapping, the seams being calked. Where the build is too light to admit calking, a narrow batten or riband is run along the seams inside, the calking being in this case limited to the garboard seams and the butting ends of the planks.

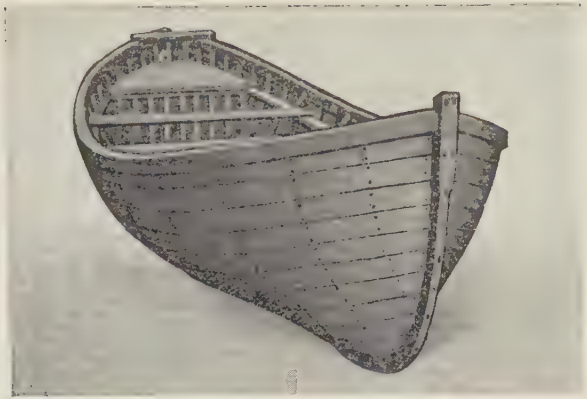


Fig. 1. Carvel.

Fig. 2. Clinker.

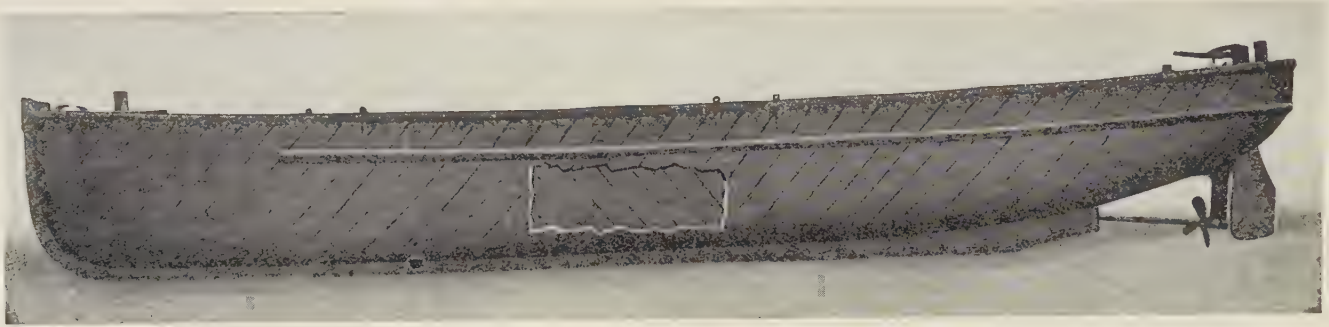


Fig. 3. Diagonal.

Where heavy boats are built on this system, a second layer of planking is sometimes used inside the frames.

In *Clinker* building (Fig. 2), the planks overlap at their edges like the clapboarding on a house, and are fastened to each other as well as to the frames. As the planks thus support each other, this system has greater strength for a given weight than the Carvel building and the frames can be placed farther apart. On the other hand, the planks are liable to split along the line of fastening, and repairs called for by this or other injuries to the boat are made with some difficulty because of the necessity of removing several planks to repair one. The seams are not calked, the swelling of the planks causing them to bind tightly upon each other. To keep them tight, the boat should be put in the water frequently, or, if that is impracticable, well wetted with a hose from time to time.

In *Diagonal* building (Fig. 3), the planks run diagonally at an angle of 45° from the keel to the gunwale and two thicknesses of planking are used, at right angles to each other. No frames are needed. This is a strong system of building, but necessarily a heavy one. As a rule it is used only for large boats carrying heavy weights.

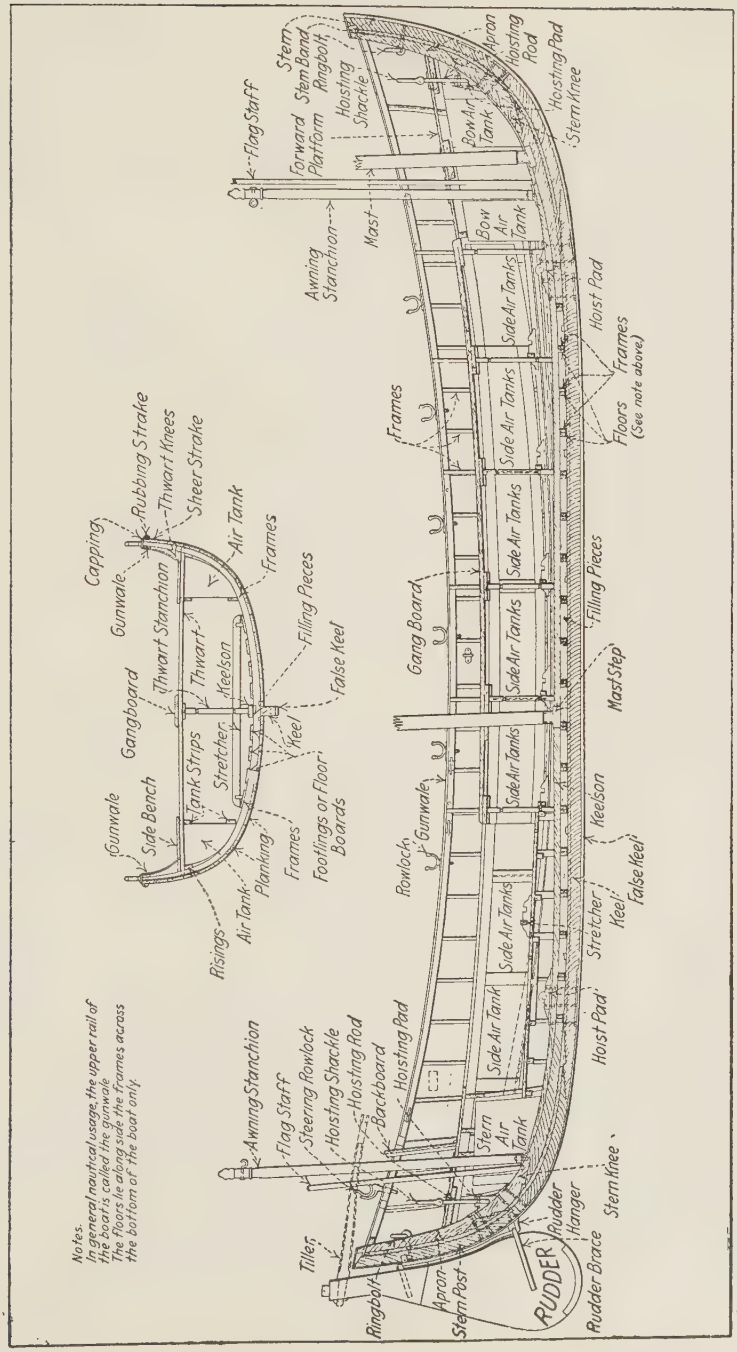
The Carvel and Diagonal Systems are sometimes combined, two layers of planking being used, one Carvel laid, the other Diagonal.

The parts of a boat are shown on Plate **64.**

In the United States Coast Guard Service, which probably has as much experience with beach or surf boats as any other similar organization in the world, metal has been entirely discarded for wood.

Metallic Boats. The plating of metallic boats is of sheet steel, galvanized. The keel, stem and stern-post are usually of steel. The gunwales are sometimes wood, but more often they are steel angle bars.

Especial precautions should be taken in the design to make all parts accessible for inspection, drying, cleaning and painting, to prevent damage from rusting and galvanic action; the danger of such damage being the principal objection urged against this kind of boat. Another objection is, of course, that unless buoyancy is provided by air tanks or other artificial means, the boat will soon sink if it fills or capsizes, whereas a wooden boat



PARTS OF A BOAT.

under these conditions will not, but will provide a limited degree of support for the crew. Practically all Merchant Marine life boats are metallic.

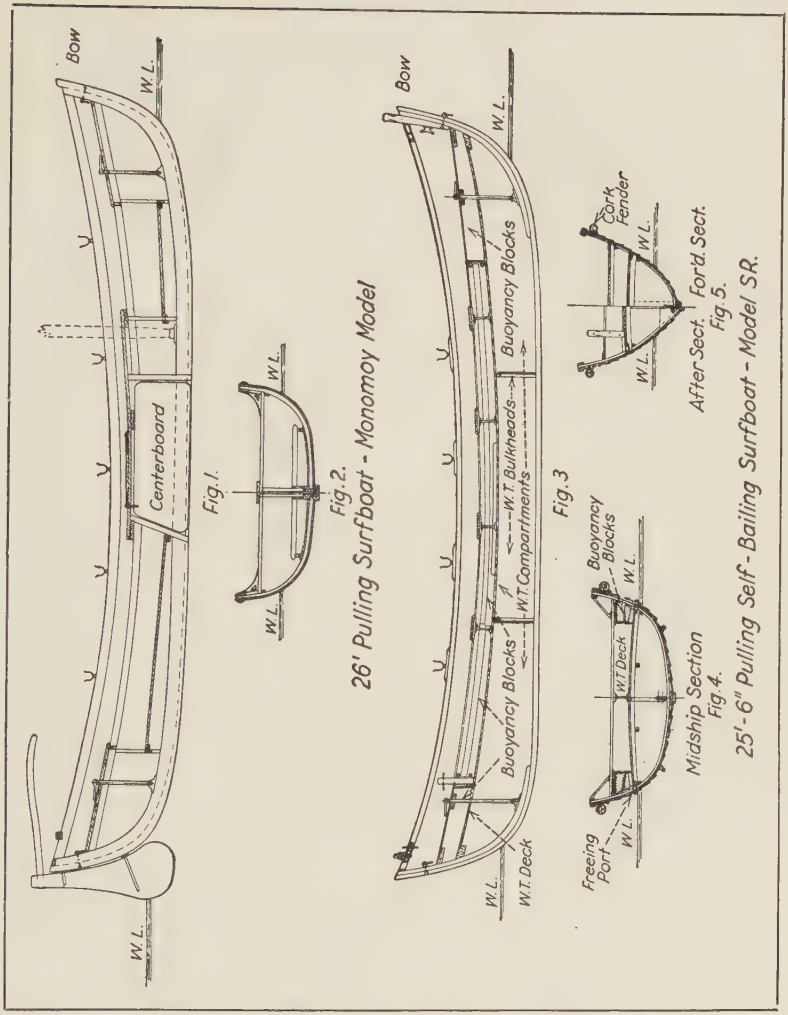
Buoyancy of Boats. Boats, whether of wood or metal, usually are fitted with air tanks for reserve buoyancy. Such tanks are of copper, or galvanized sheet steel. Some boats such as those used by the Coast Guard obtain their reserve buoyancy through fitted in, water-proof "balsa" buoyancy blocks.

The position of the air tanks, especially as regards height, is an important consideration. If carried high, they tend to keep the boat from capsizing and help to right it if it is capsized; but if about the thwarts, they reduce the space available for passengers and interfere with the handling of the oars. If carried low, they keep down the center of gravity of the boat, not only by their own weight but by lowering the seating space for passengers, but this advantage is offset by the fact that they actually increase the difficulty of righting the boat if it is capsized. The general practice is to place them outboard below the thwarts (See Plate **64**).

Self-Bailing Boats. (Plate **65**, Fig. 3, and Plate **66**.) In a self-bailing boat, a watertight deck runs throughout the length of the boat slightly above the load water line. The space below is thus converted into a watertight compartment. Water from this deck runs overboard through freeing ports in the side of the boat. Evidently this system cannot take care of any water which may enter the compartments below the deck from leaks in the side or bottom of the boat. Such water is pumped out by hand-pumps and if discharged onto the deck, flows off through the freeing ports like water from a breaking sea.

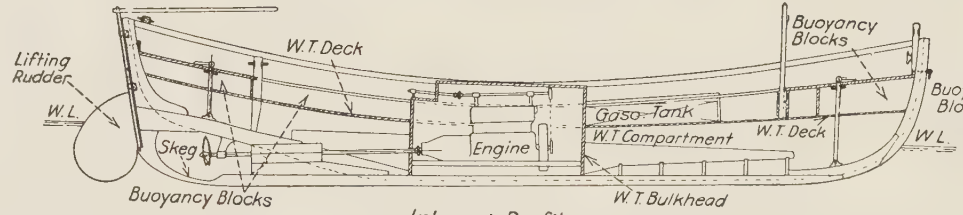
Self-Righting Boats. (Plate **67**.) It is evident, as already explained, that if the buoyancy of a boat can be carried very high there will result a tendency for the boat to right itself if it is capsized, and that this tendency will be increased if the keel is made as heavy as practicable. Self-righting boats are accordingly built of such a shape as to admit of carrying the bow and stern air tanks very high, and are fitted with a heavy keel of iron or lead.

The self-bailing and self-righting features are sometimes combined, but only in large boats (Plate **67**).



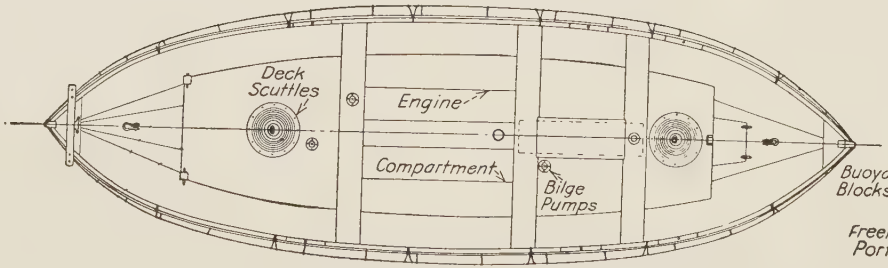
Boats of the United States Navy.

A large part of the Navy's work is carried out by means of its small boats and their design is largely determined by the following considerations: They must be durable, seaworthy, sturdy but easily repaired, have a relatively large capacity for personnel or cargo, must be capable of being hoisted aboard in a seaway and of being stowed compactly and securely against any weather which might be encountered. Wooden construction is used exclusively.

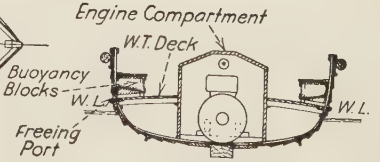


Inboard Profile
Fig. 1.

Section at For'd Engine Compartment
Fig. 3

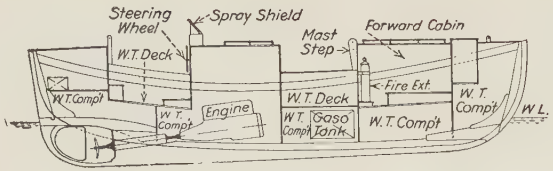


Deck Plan
Fig. 2.

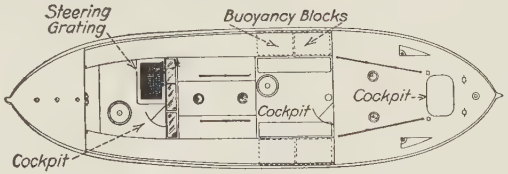


Midship Section
Fig. 4

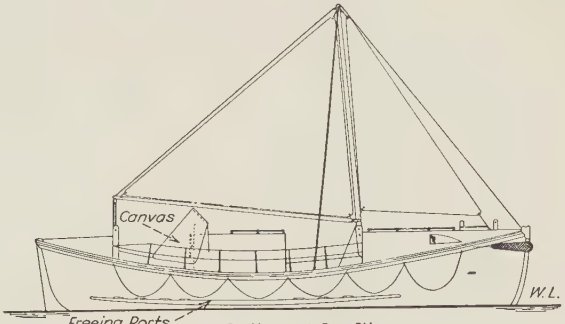
25'-10" Motor Self-Bailing Surfboat - Model - SR.



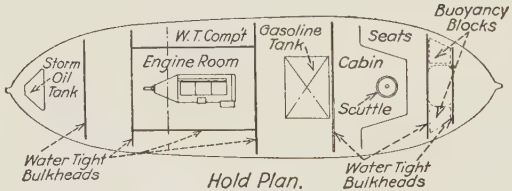
Inboard Profile.
Fig. 1.



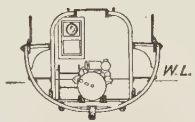
Deck Plan.
Fig. 2.



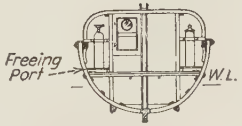
Outboard Profile
Fig. 4.



Hold Plan.
Fig. 3.



Section Engine Room
Fig. 5



Section Forward Cabin
Fig. 6.

36'-8" Motor Lifeboat, Type "TR"-Self-Bailing, Self-Righting

The standard boats used by the United States Navy are classified as follows:

Power boats:

Motor boats.
Motor launches (Fitted with sails only on specific approval by Bureau).
Motor whale boats.

Pulling boats:

Whaleboats (Sails are included in outfit).
Dinghies (Sails are included in outfit).
Wherries.
Punts.
Racing cutters.

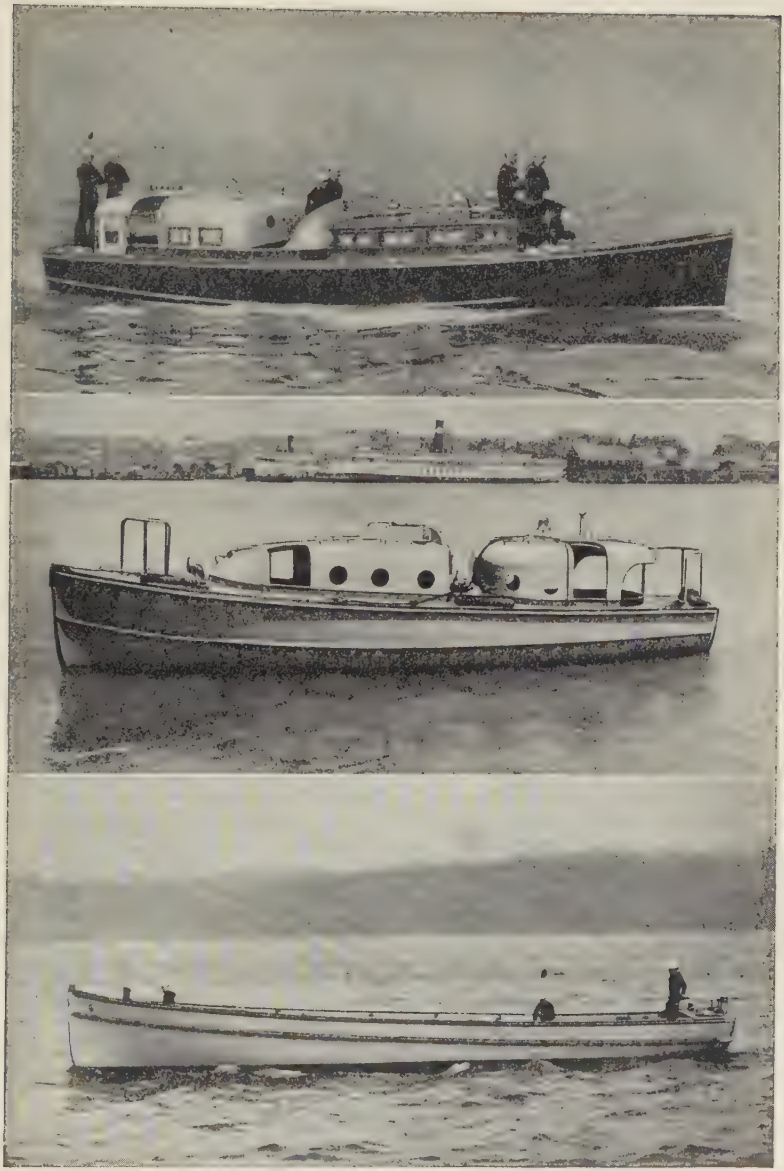
Standard boats are frequently altered and fitted with special equipment for such purposes as airplane salvage work, gasoline delivery and survey work. In addition, a number of boats are built for special purposes, such as aircraft rescue boats, survey boats, sail boats, surf, landing and beaching boats and torpedo retrievers.

Standard boats used by the U. S. Navy may be briefly described as follows:

Motor Boats (Plate **68**) are fitted with metal canopies and are used as officers' boats and for dispatch service. Motor boats used by flag officers are known as "barges," and those used by Commanding Officers as "gigs"; "barges" are generally transferred from ship to ship with the flag. Motor boats are not fitted to mount guns.

Motor Launches (Plate **68**) are open boats for heavy duty having square transom sterns. They are designed for such service as carrying stores, liberty parties, kedging, etc., and are frequently fitted with special equipment for survey work. With the exception of the 24- and 26-foot launches, all are fitted for mounting a light gun in the bow.

Motor Whale Boats (Plate **69**) are double-ended boats, which are convenient for a wide variety of light duties. Large ships are supplied with the open type, for use as life boats in addition to the pulling whale boat. The hooded type, which serves as an officers' boat, is furnished to vessels that have no other canopied



UPPER—BARGE; CENTER—MOTOR BOAT; LOWER—MOTOR LAUNCH.

HOODED MOTOR WHALEBOAT

METHOD OF TRANSPORTING SURF BOAT
U. S. COAST GUARD.

Fig. 1. Navy 26-Foot Motor Whaleboat.

Fig. 2. Surf Boat with Drogue, Steering Oar, etc.

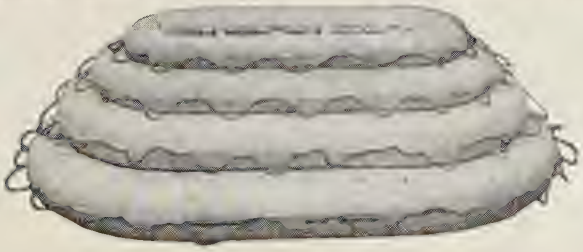


Fig. 3. Life Rafts.

boats. Both types have a steering oar which may be shipped for life boat duty.

Whale Boats (Plate **77**) are pulling boats, pulling 5 oars single banked (24-ft. size), and 12 or 10 oars double banked (30-ft. and 28-ft. sizes, respectively). They are sharp at both ends. The 24-ft. boats are fitted with a lug rig, without centerboard. The 30-ft. boat, issued only to large ships, is designed especially for sailing and has a ketch rig and centerboard. All whale boats are fitted with swivel rowlocks and for life boat work are provided with a steering rowlock. Whale boats are used as life boats, although the open-type motor whale boat is generally preferred.

Dinghies are small handy boats with transom sterns. They are pulled by three or four men, each with one or two oars, depending on the size and design. Owing to the small crew required, they are particularly convenient for nearly all light work in port. They carry sails and are sprit rigged.

Wherries are light, handy boats with transom sterns. They may be pulled by two or three men, each using two oars, and are not furnished sails.

Punts are square-ended, flat-bottomed boats, intended for painting and general cleaning around the ship's water line. They are fitted with rowlocks but are usually propelled by sculling.

Racing Cutters are lightly built boats with transom sterns, designed to stimulate interest in oarsmanship and for recreational competition. While they are sturdy and strong for the purpose intended they are not suitable for general use and are not provided with sails. They are issued only to the larger ships. As these boats are used in competitive racing, all alterations and changes without Bureau approval are prohibited.

Boats of the United States Coast Guard.

Coast Guard boats are generally of a specialized design developed over a long period to meet the particular demands of the Service. Typical construction includes white oak framing, cypress planking, copper rivet or bronze screw fastenings, monel bolts, and composition castings. Practically no ferrous metal is used in hull construction. Buoyancy is never sought through the use of metal tanks. Special attention is paid to strength and

reliability, and power boat designs usually provide good protection for rudders and propellers.

The Motor Life Boat (Plate **67**), and **Self-bailing Surf Boat** Plate **66** and Plate **65**, Fig. 3) are the most highly specialized designs. Both types are self-bailing. This feature is obtained in the latest boats by means of a deck located well below the gunwale but slightly above the normal waterline. Water from this deck runs overboard through freeing ports in the sides of the boat. The self-righting feature of the life boat is obtained by high, watertight compartments at the bow and stern, a watertight engine compartment, and a bronze false keel weighing about 1800 pounds. Both the life boat and the self-bailing surf boat hulls have watertight compartments below the waterline and built-in buoyancy spaces filled with neatly fitted balsa wood blocks above the waterline.

The motor life boat is a ruggedly built boat, capable of operating in practically any sea. Because of its weight, it cannot be launched from the beach, but must proceed from inlets or protected waters.

The Motor Self-bailing Surf Boat (Plate **66**) is particularly adapted to use in the surf because of its handiness and its self-bailing design. This boat is not ordinarily launched from the beach into a heavy surf, but it may readily be transported overland by trailer to suitable launching places. (Plate **69**.) It is used on cutters and at many surf stations, and has given excellent service during flood relief duty on the rivers of the interior.

Other Coast Guard boats are less specialized in design. The **Picket Boat**, intended primarily for law enforcement, is designed for maximum speed consistent with strength and seaworthiness.

The **Motor Launch**, issued to ships, is a small boat of conventional design in which are sought qualities of ruggedness, seaworthiness, and speed.

The Self-bailing Surf Boat (Plate **65**, Fig. 3), propelled by oars only, is found at most surf stations and is carried by cutters. It is frequently launched from the beach directly into the surf. (Plate **93**.) For landing personnel and stores on a beach through heavy surf, this boat is probably the most suitable type available.

Monomoy Surf Boats (Plate **65**, Fig. 1) are carried by Coast Guard cutters as life boats and for general ship's use. They are

substantially built, double-ended pulling boats with full lines, having good carrying capacity and excellent seaworthiness.

Power Boat Engines—U. S. Navy.

Power Boat Engines. In the relatively short time since the adoption of machinery for the propulsion of the Navy's boats, there have been many changes in the type of prime mover employed. Reciprocating steam engines, two-cycle gasoline engines, steam turbines, four-cycle gasoline engines and Diesel engines have succeeded or paralleled one another. Coal, bunker oil, gasoline, and Diesel oil have in turn provided the source of energy.

Today there are no steam-driven boats in active operation and the last of the two-cycle gasoline engines has disappeared from the Fleet. All newly constructed vessels are being placed in commission with Diesel-powered ships' boats. A replacement program has been drawn up to provide for the installation of Diesel engines afloat as the gasoline engines are retired when beyond economical repair. Several years will be required to complete the Dieselization of the Fleet's power boats.

The virtues of the Diesel engine for motor boat use have long been recognized. The elimination of the ever-present fire hazard of gasoline has alone been sufficient to keep continual pressure behind the development, and this has been primarily responsible for the early entry of the Navy into the manufacture of Diesel engines for its boats. There are in addition other advantages such as economy and longer radius of operation which hastened the change. However, the need for many mechanical developments such as satisfactory starting at low temperatures, weight reduction and clear exhaust delayed it. In 1934 the Navy purchased designs and commenced manufacture at the Norfolk Navy Yard of three types of Diesel engines. These were the type DA, which developed 25 horsepower at 1425 revolutions per minute in four cylinders; the type DB, which developed 60 horsepower at 1700 revolutions per minute in six cylinders; and the type DC, which developed 105 horsepower at 1190 revolutions per minute in six cylinders. The type DC proved too expensive and too heavy and was soon superseded by the type DD,

a six-cylinder engine which developed 105 horsepower at 1800 revolutions per minute.

In making the change from gasoline engines to Diesel engines, an effort has been made to take advantage of developments in other fields, where applicable. For example, all the Diesel engines are being installed on rubber mountings with a flexible rubber coupling in the propeller shaft, thus insulating the engine vibrations from the hull. This is no more necessary in boats than it is in automobiles but the result has been equally pleasing. Reduction gears have been installed in the Diesel engines to give a propeller revolutions per minute of about 700 at the Diesel engine rated speed. This slowing down of the propeller materially improves the maneuvering qualities of the boat. The difference between the gasoline-driven and the Diesel-driven boats from this standpoint is readily apparent.

In view of the fact that gasoline-driven boats will be in the Navy for some years to come, too much emphasis cannot be placed upon the necessity for observing safety precautions to avoid gasoline fires. Universal familiarity with automobiles and the fact that gasoline fires rarely occur in them tends to breed contempt for the hazards connected with the use of gasoline in boats. Gasoline leakage from a car falls to the ground and, even in an enclosed space, as a garage, the liquid or its fumes drain off so rapidly that an explosive mixture is very rarely obtained. In a boat, on the other hand, all of the liquid drains to the bilge, and such vapor as is given off, being also heavier than air, lies there until swept up by air currents such as the convection currents around a hot engine. Experience has shown that with high-tension ignition systems the Navy must accept the fact that sparks external to the engine are present most of the time. The Diesel engine eliminates this source of ignition but its principal virtue really lies in the fact that it uses a fuel the flash point of which is well above normal temperatures, and, therefore, fuel which may accumulate in the bilge does not give off vapors which, in the case of gasoline, form the explosive mixture and need only a spark to start the fire.

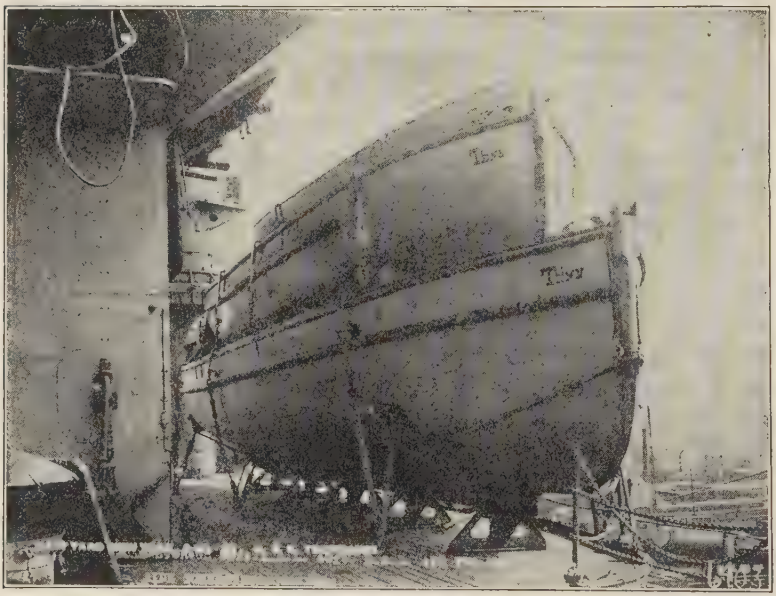
Stowage and Handling of Boats.

Stowage of Ships' Boats.

Methods Used. Boats are stowed on naval vessels in such a manner as to interfere least with the vessel's assigned duty.

In battleships, they are nested one inside the other (Plate **71**), properly chocked up and then griped down in place to insure their security in a seaway. The boats are so nested that the

Plate No. 71

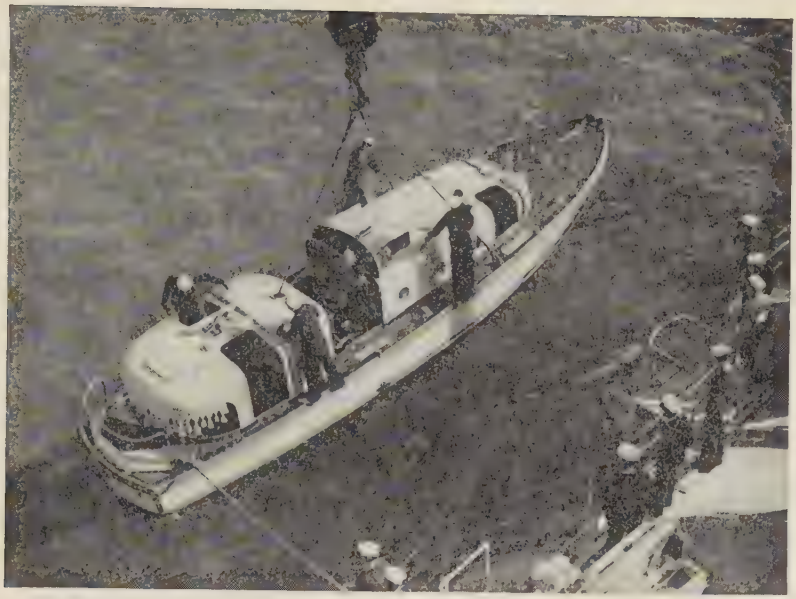


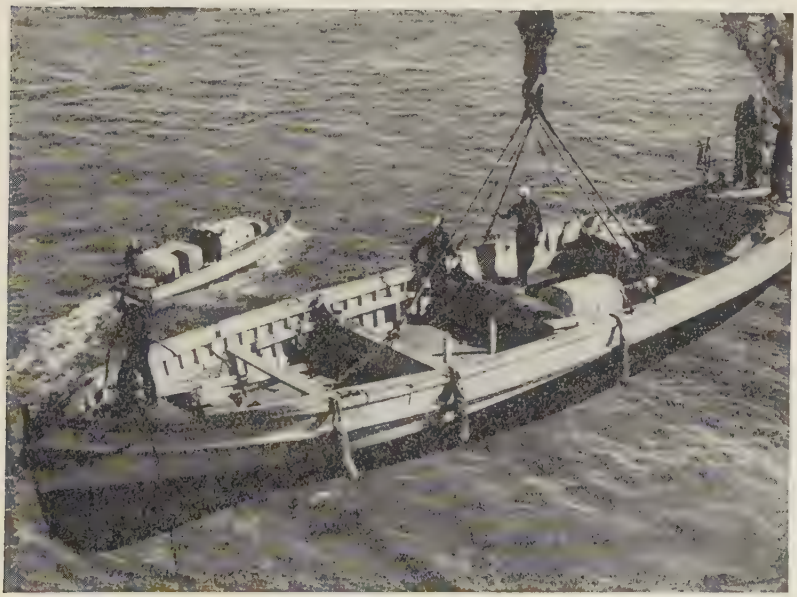
NESTING BOATS.

crane falls plumb the boats. This method provides a compact stowage and uses little deck space. The top boat of the nest is usually the motor life boat, with slings hooked on and ready for sea. On each quarter, a life boat, either pulling or motor-propelled, is usually carried rigged out from the boat davits.

Aircraft Carriers carry their boats stowed in boat pockets in the side of the ship under the flying deck.

Cruisers, light craft, and auxiliaries carry their boats under booms or in chocks under radial arm boat davits.





HOISTING OUT.

Motor Boat (*above*). Motor Launch (*below*).

In submarines, the boats stow in wells in the deck. A boom plumbing the well may be rigged for handling the boats.

It is imperative that all boats fit snugly in their cradles or chocks and be griped down securely to the deck. The keel of a single boat, or a bottom of a nest, should be set evenly on a skid or I-beam throughout its length. In the case of nested boats, each boat in the nest should be so supported that its weight is taken up by the keelson of the bottom boat. Where a ship is subjected to heavy rolling the securing gripes should be taken down to the deck for each boat in the nest.

Hoisting and Lowering Devices.

Booms, Cranes and Davits.

Boats of light draft and auxiliaries are handled by booms or by davits of heavy construction, which are so rigged that the hauling part of the falls may be led to a winch.

The boats of aircraft carriers, which stow in boat pockets, are handled by heavy power davits or cranes so designed and located as to serve the boats and still be clear of the side and the flying deck when in their securing positions. The davits on some carriers are of both the quadrantal and radial arm type of special design and are arranged in pairs, while some carriers have boat cranes located in the side of the ship between the two adjacent pockets whose boats they serve.

Battleships have strong single-column cranes with powerful, variable-speed motors which handle the boat by wire falls.

For hoisting boats, wire rope slings are used, the fore and aft wire rope legs being shackled to chain bridles that are shackled to hoisting pads on the keel. Manila rope side guys hitched to chain plates are used to keep the boat upright and are not intended to take any part of the weight of the boat in hoisting. Motor boats handled by the crane have only three wire legs and no manila side guys. (Plate **72**.)

Boats of aircraft carriers using davits have two sets of slings, one set forward and one set aft, each being attached to its appropriate fall. Wire falls and ordinary hooks fitted with safety runners are used in this case. Each fall may be independently controlled.

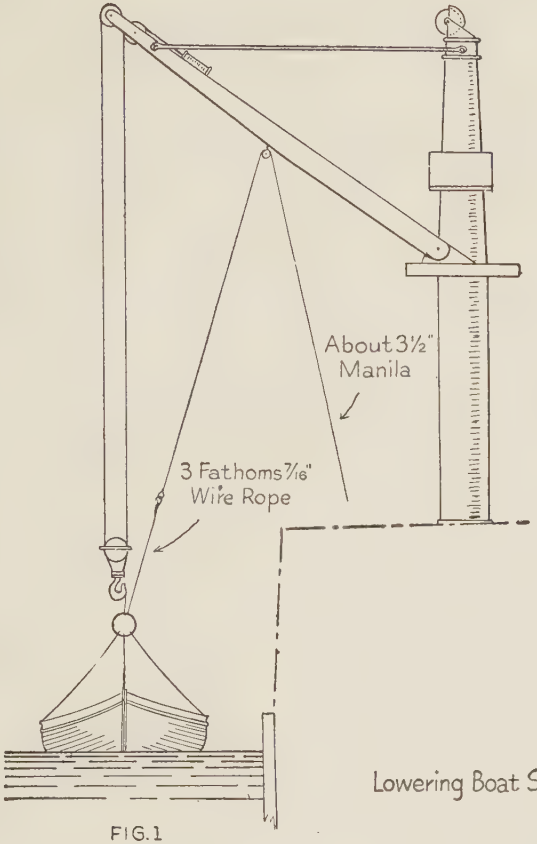


FIG. 1

FIG. 2

Lowering Boat Slings

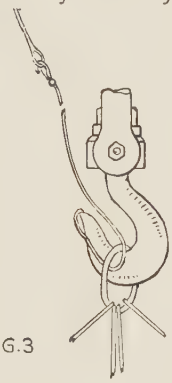
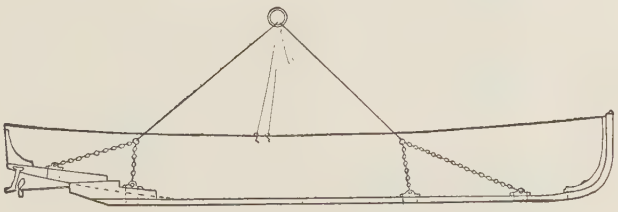


FIG. 3

Lowering Boat Safety Runner Rigged



Slings for Hoisting a Heavy Boat

FIG. 4

Releasing Gear.

The *Safety Runner.* Plate **73** shows the boat crane of a battleship and the slings and other fittings for hoisting a heavy boat. As the slings and the crane-block are heavy and unwieldy, the matter of handling them is always difficult and becomes dangerous when the boat is tossing about in a rough sea. The matter is greatly simplified by the use of the safety runner.

This device consists of a wire which is about 3½ fathoms long and made fast to the hook of the crane-block. The wire has an eye worked in the free end and the standing part is attached to the point of the hook. To the eye of the wire runner, a manila tripping line is attached by either a hitch or a snap hook.

The *Tripping Line* leads from this eye to a block on the arm of the crane and thence down on deck where it is belayed and the end coiled clear for running. To lower a boat, the ring of the slings is hooked on the crane hook and also in the bight of the safety runner. When the boat is water borne and the slings become slack, a pull on the tripping line, which is tended on deck, straightens out the bight of the runner and lifts the ring out of the hook. If it is desired to hook on (slings not in boat), and the boat can be kept reasonably well under the crane, the slings may be lowered in the bight of the runner within reach of the boat's crew, who attach the slings to the boat. In a comparatively calm spell, the block may then be lowered and the slings run onto the hook by a pull from the deck on the tripping line.

Should the weather not permit this, the slings may be tripped into the boat as above described. The boat may then lie off, attach the slings, then come under the crane. The bight of the safety runner is let down so that it may be reached and broken at the eye by the boat's crew. The runner is then rove through the sling ring and the ring engaged to the crane hook by a pull on the tripping line as described above.

Raymond Releasing Gear.

Plate **74** shows a form of releasing hook used in the United States Navy. The releasing hook can act only when the boat is water borne, as the weight of the boat at other times holds up

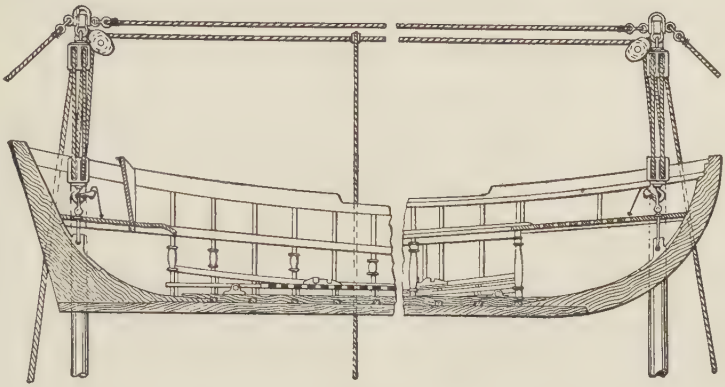


FIG. 1.

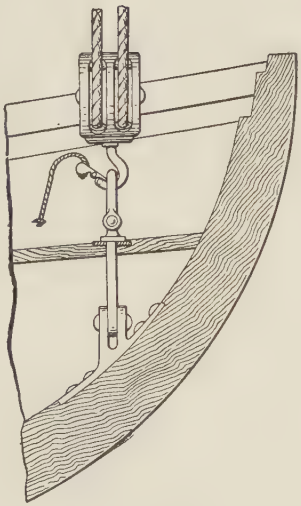


FIG. 2.

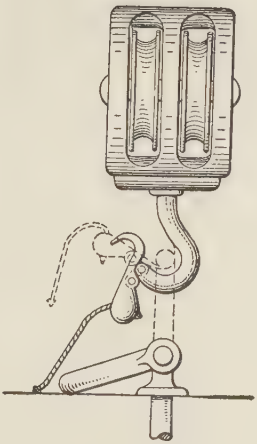


FIG. 3.

AUTOMATIC RELEASING HOOKS (U. S. NAVY).

the movable part of the hook. For hooking on, a lanyard attached to the point of the hook is rove through the hoisting link in the boat and the hook is pulled through with this and held up in place until jammed by the weight of the boat. The hooks should be rove through the hoisting links from forward aft for the forward fall and from aft forward for the after fall.

The Motor Life Boats.

Requirements.

The Naval Regulations require a life boat to be always ready for immediate use. The *motor whale boat,* when used as a life boat, is secured for sea when in the following condition: If carried under the crane it is set up in chocks (usually the top boat of a nest), griped down with gripes of 2½-inch manila line with a pelican hook or toggle for quick release; forward and after steadying lines rigged and coiled down on deck clear for running; sea painter secured as in the pulling whale boat, and led forward clear of everything; gasoline tank full of fuel; engine tested hourly; life preservers; water, etc.; as for a pulling life boat; and in addition, the regulation fire-fighting equipment required for motor boats. The ring of the boat sling is kept on the hook of the crane, tripping line (safety runner) to the crane rove off, and coiled clear on deck for running. Where the motor life boat is carried rigged out on davits, it is lowered in the same manner as the pulling boats, which is described later. Spare oars are carried. The coxswain, after a careful inspection, reports his boat ready at the beginning of each watch.

Lowering and Hoisting. (Motor Life Boat.) (Plate **75**).

With the crane manned and ready, the slings hooked on over the bight of the safety runner, the boat is lowered away on signal. The slack of the sea painter is taken in as the boat is swung out. The boat, with the engine running, is lowered to just clear of the water. When all is ready, it is quickly lowered, and when water borne the slings are tripped from the crane hook, the steadying lines are released, the boat sheered out, and sea painter released.

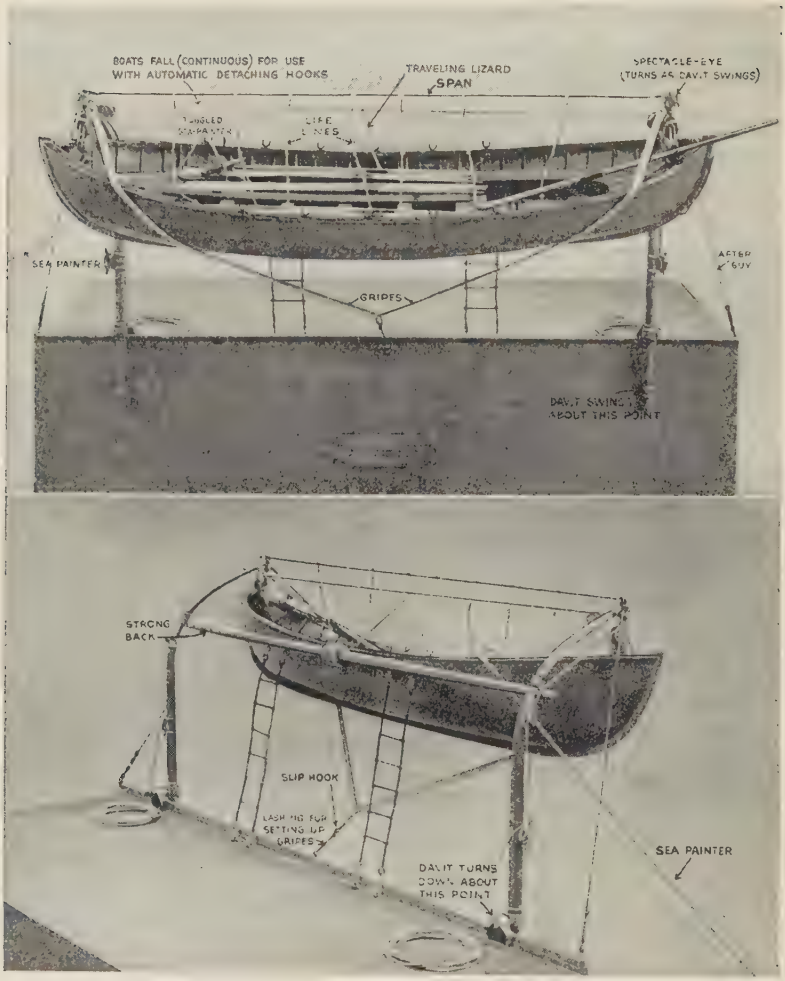
To hoist, the boat is brought under the crane block where the steadying lines and sea painter are passed. At an opportune moment the comparatively light slings are engaged to the crane hook and the boat is hoisted. If the ship is making way through the water, the stern line should be carefully tended to prevent the boat from surging forward when it leaves the water.

Plate No. 75

MOTOR LIFE BOATS READY TO LOWER

The Pulling Life Boat.

A *Pulling Life Boat* (See Plate **76**), is secured for sea, *i.e.*, ready for lowering, when in the following condition: Boat at davits, rigged out, griped against the strongback, gripes secured with a slip hook; falls clear, and secured to cleats in such a manner as not to jam; detaching hooks tended and ready for detaching; steering oar in crutch; oars ready for getting out quickly, oarlocks shipped and fitted with lanyards; plug in; sea painter with a long lead forward and outboard of everything, brought aboard and toggled around the second thwart near the inboard gunwale; life lines bent to span; frapping lines ready for use; life



(TOP) ROUND BAR DAVITS WITH LIFE BOAT FROM MODEL U. S. NAVAL ACADEMY.

jackets in boat; lantern filled and trimmed (and at night, lighted); and all articles of the boat equipment in the boat and ready for use, with two days' water for the crew. When the coxswain of the life boat crew reports ready for lowering, it is understood that the boat is in the above condition and that the crew has been mustered and inspected. If the ship has two life boats, both are reported by the same coxswain.

The motor life boat may be hung from the davits and secured in the same manner.

Lowering the Pulling Life Boat. (Plate **77**.)

To lower a pulling life boat, a lee boat is always selected, a lee being made, if necessary, by changing the course of the ship.

It is customary to bring the sea a little on the opposite bow, but in this position the lee for the boat is far from perfect. The ship will roll and pitch considerably, and waves will wash along to leeward, making things very ugly at times. Some seamen prefer to bring the sea on the quarter rather than on the bow, others advise lying in the trough of the sea, notwithstanding the heavy rolling. In case of a cross sea, the surface chop is more to be feared than the roll or pitch. The best position will doubtless depend on the build and trim of the ship and the nature of the sea. The ship should be kept moving slowly ahead and in case of heavy weather, oil should be used.

To keep the boat from swinging, frapping lines (See Plate **77**) may be passed from the deck around the falls. The ends lead back inboard and are tended on deck and hold the boat close in to the side of the ship as it is lowered.

Another method is to rig around the falls an iron ring, large enough to pass over the blocks. A stout line attached to this ring and tended on deck allows the boat to be held in close to the side during hoisting or lowering and yet not jam in the block, as frapping lines are liable to do when hoisting.

Knotted life lines hanging from the span give the crew something to hang on to in case of accident. A hatchet in the boat should be handy in case anything jams.

The great danger, both in lowering and immediately afterwards, is that the boat will be dashed against the side as it takes the water. If the ship has a little headway, the painter brought

LOWERING—SMOOTH SEA

SHOWING USE OF FRAPPING LINES.

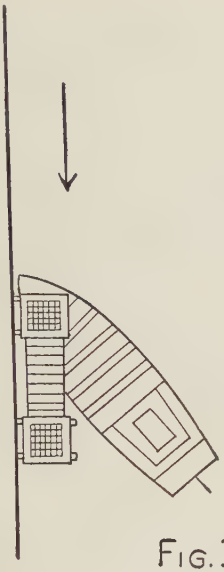


FIG. 1

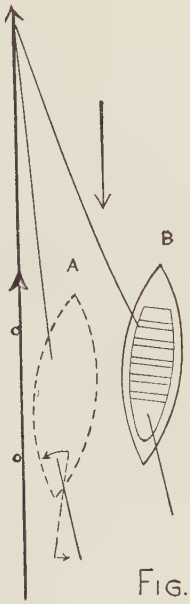


FIG. 2

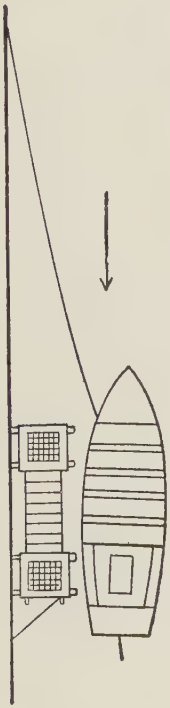


FIG. 3

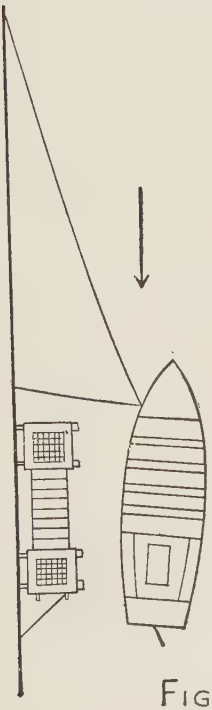


FIG. 4

LANDINGS—ACTION OF SEA PAINTER.

in on the inner bow shears her off as she strikes the water. (Plate **78**, Fig. 2.)

Where a motor whale boat, using only a tiller, is being lowered from the davits, the tiller may be held hard-over toward the ship for the same purpose.

A steering oar is better for this purpose than a rudder and should always be shipped ready for use in the motor whale boat.

The after fall is always unhooked first, except when a detaching apparatus releases both falls simultaneously. Should the ship have headway and the forward fall unhook first, the after fall may jam, swinging the boat around and in doing so capsize it.

When lowering a life boat at sea, it is always desirable to have a little headway on the ship in order that the sea painter may be of use in sheering the boat clear of the side. (See Plate **78**.) There is much difference of opinion as to the speed at which it is safe to lower a boat but a conservative view fixes the maximum at from four to five knots. Most practical seamen prefer to wait for the ship to slow to this speed rather than take the chance of swamping the boat and dealing with a whole boat's crew in the water.

When all is ready, the boat is lowered to the rail where the men on deck steady it. On signal, the boat is lowered smartly and when within a few feet from the water, the falls are thrown off and let go with a run. This assures the release of both hooks of the falls before the sea painter takes the strain. The sea painter should have no slack in it as the boat takes the water.

Should there be no headway on the ship, and the sea smooth, the sea painter should be immediately cast off when the boat is water borne and the boat breasted clear of the ship by the oarsmen. In rough weather, pulling on the sea painter by men on deck or passing the painter aft and pulling on it by the boat's crew will assist in sheering the boat clear.

Hoisting the Pulling Life Boat. (Plate **77**).

In a seaway, to hook on and hoist the boat is as difficult as to lower and detach it. The ship is handled in such a way as to make a good lee, and it is well that she should be moving very

slowly through the water, but the screws should be stopped while working with the boat. Before the boat returns to the ship the falls are overhauled, ready for hooking on and are held clear of the boat by men on deck. This is necessary in order to eliminate the possibility of hitting the men in the boat with the heavy blocks. The falls are well manned, with power enough to *run away* when ordered to do so. If a winch is to be used, the proper turns are taken loosely around the drum and the winch is started. The sea painter, from well forward, is led aft on deck, and then passed to the bow oarsmen by means of a heaving line.

The officer who is to direct the maneuver should take his place as close as possible to the point where the boat is to be hoisted.

As the boat pulls near the ship abreast of her falls, the bow oarsmen boat their oars and stand by. The sea painter is passed to the boat and a turn is taken around the forward thwart near the inboard gunwale. The oars are then boated as quickly as possible and the boat is eased alongside the ship and into position under her falls by careful use of the steering oar; being hauled ahead or dropped back slowly, as necessary, by the sea painter, which is tended on board the ship. If the coxswain is skillful, he will work the boat in slowly, first canting her head slightly toward the ship and then catching her before she can touch, by throwing her stern in enough to straighten her up parallel to the ship.

Two men in the boat stand by to breast her off with the wooden end of the boat hooks. In case the ship is rolling badly, frapping lines and fenders are used.

The men who are to hook on forward and aft, see the hoisting shackles or links in the boat ready and stand by the lower blocks. Oil should be used to calm the sea if necessary. When all is ready in the boat and on deck, an opportune time is watched for and as the ship starts to roll towards the boat, the falls are hooked on forward, then aft; then the order is given to: "Set Taut!", "Hoist Away!"

If the ship is making good way through the water or pitching, a line should be used from the stern of the boat, leading well aft on the ship, to prevent the boat from surging forward as she leaves the water and during hoisting.

Lowering and Hoisting Boats in Bad Weather. (cranes or booms.)

Lowering. A lee is first made and it is preferable in this case to have no way on the ship. Heavy steadying lines are secured to the bow and stern of the boat and are well tended by men on deck. The safety runner is rigged (See Plate **73**). The boat is lowered until just clear of the water, and at a favorable moment, is lowered quickly into the water. As soon as the boat is water borne, the ring of the slings is run clear of the hook by a pull on the safety runner. When the ship is rolling or pitching, steadying lines should be used on the crane blocks. The boat's engine should be running before the boat takes the water. Round fenders should be hung over the bow and quarter of the boat.

Hoisting. When all preparations have been made, including hanging the slings from the bight of the safety runner, the boat is worked up under the crane, the bow line, stern line and steadying lines passed, and the crane block lowered. The slings hang slack in the bight of the runner while the legs are shackled to the boat's hoisting chain bridle. (Plate **73**, Fig. 2.)

When hoisting in a seaway, using a crane or boom, there are three principal difficulties to be met:

First, after hooking on and hoisting has commenced, the boat may retouch the water as the ship rolls, with a violent jerk which may be destructive to hoisting gear. To avoid this, advantage is taken of a quiet moment, and, when the ship has commenced to roll toward the boat or the boat is on a high wave, the crane block is quickly lowered, the ring of the slings is run onto the crane hook by the safety runner, and hoisting is commenced. This calls for accurate timing only possible with experienced personnel.

Second, the ship's rolling may cause the boat to swing into the side of the ship as it is being hoisted. This difficulty is met by the use of stout steadying lines, well tended forward and aft and by the use of fenders hung over the boat's side. By properly tending these lines, taking in and holding the slack as necessary, the swing may be somewhat reduced, the action of the steadying lines being similar to that of frapping lines. Where the boat is making headway through the water or the ship is pitching badly, a long bow line and stern line should be used to

help reduce the surge fore and aft as the boat is being hoisted.

Third, after hoisting and swinging in, great difficulty is sometimes encountered in plumbing the boat's stowage for a sufficient period of time to enable it to be lowered quickly and accurately into place. Here steadying lines are a necessity and it is advantageous, especially where the boats stow close to the ship's side, to have four steadying lines, two forward and two aft. These lines should lead from the opposite sides of the boat at the bow and stern so as to cross and thus give a better lead for steadying the boat into position as it is lowered.

Handling a Power Boat Underway.

The laws governing the steering of a power boat are identical with those laid down in Chapter XIV for handling of single-screw steamers, but since the proportion of power, rudder area and freeboard of the boat to the corresponding characteristics of the large ship is usually greater, the boat's reactions to the engines and rudder are much more pronounced.

When underway in a seaway, speed should be reduced somewhat, not only to avoid shipping seas, but also to reduce the strain on the hull and on the machinery due to the "racing" of the screw. Navy boats have good power, and boats, especially open boats, such as motor whale boats, may be swamped by forcing them against the sea. In heading into a sea, it is possible, by careful nursing to make fair speed, watching the seas and slowing, or even stopping for a moment as heavy ones are seen bearing down upon the boat. If the man who is running the engine has sufficient experience to regulate the speed in this way (assuming that he can see), it is best to leave it to him. As in steamers, the boat may sometimes be made to ride much easier when, instead of plunging head on into the sea or running directly before it, a course is made with the sea on the bow or quarter. If running more or less across the sea, it is well to head up momentarily for a heavy wave.

A large motor launch has a high bow and has difficulty in turning against the wind and sea. A large turning circle may in this case be expected and should be allowed for in narrow waters.

Attention should be paid to the weights, especially in a head sea; too much weight forward may cause her bow to plunge into the waves; too much aft will cause her to fall off. When running before a heavy sea, weights aft will reduce yawing but too much weight aft may allow the boat to be pooped.

Wind and current should always be observed and allowed for when leaving the ship or landing, and the compass course and time to destination noted, in order that the proper course may be steered in case of fog.

In picking up any floating object which may be injured by contact, such as a floating plane or a man in the water, always maneuver for such a position, that when stopped, the boat and the object will be separating. In the case of the plane (plane drifting faster than boat), go to windward; in case of man overboard, go to leeward.

Coxswains should be careful in passing small open craft, men working on floats, or divers working from a boat, to slow down so as not to give them their wash. Neglect to do this is not only bad sea manners, but in some cases dangerous.

Never cut a pier head or the bow or stern of an anchored ship too closely. A collision with another reckless boat might occur.

Making a Landing.

In making a landing, whether at a pier or at a ship's gangway, it is a common mistake to keep too much way on the boat. The fact is overlooked that conditions of load and trim materially affect momentum. The landing should be approached at such an angle and at such speed that should the engine fail to back, control of the boat is still maintained and she can be sheered alongside and away by the rudder alone without injury. The engines may, and often do fail to respond promptly, and when they do respond, the sudden backing throws an undue strain upon the engines and upon the rudder stops. The backing throws the stern off to port in a right-handed screw and this should always be allowed for in the angle of approach.

Care should be exercised with an internal combustion engine to regulate its speed in going alongside so as to obviate having to throw out the clutch while the engine is running at "full," which will cause the engine to race and in time tear it to pieces.

In coming alongside a ship's gangway platform, in a current or heavy weather, care must be taken not to catch the tide or sea on the outward bow, as this will sweep the bow in, forward of the lower platform, and perhaps underneath it, with the result that the boat may capsize or be swamped. (Plate **78,** Fig. 1). Should the ship have no forward vertical fender or large cane fender, this danger is greatly increased. The landing should be made by the aid of a boat-line from forward, the boat being kept off a little from the side until the line is fast and then eased in by the rudder.

A power boat coming alongside in rough weather or in a strong tide-way should always be required to take a bow line. Crews of power boats frequently make their landings at a gangway by the aid of boat hooks alone, taking hold of anything which may chance to be within reach, and holding on, often with great difficulty and more or less danger of falling overboard. This entirely eliminates the effect of the rudder, which is the principal factor by which the situation should be controlled. A boat lying at the gangway in a tide-way and holding on by a boat line made fast to a cleat on her inboard bow, can be controlled by a touch of the rudder, which sheers the stern out or in and thus catches the current on one bow or the other. (Plate **78,** Fig. 1). Where a ship is rolling in an open roadstead or riding with the wind ahead with waves surging aft alongside the ship, the boat rises and falls dangerously at the gangway platform and contact with it may injure or capsize the boat. The need of a long boat line, in effect a sea painter is here emphasized. By using the boat line in combination with a breast line and by judicious use of rudder and engines, the boat may lie alongside of the gangway without touching it. (Plate **78**, Figs. 3 and 4).

Embarking and Disembarking in Heavy Weather.

It is sometimes impossible, because of heavy weather, to make a gangway landing. In this case the passengers may come in over the quarter boom. The rudder of the ship is put over to one side or the other, preferably to that side opposite to the anchor in use. The ship will yaw back and forth but will usually yaw more on the side away from the rudder, thus making somewhat of a lee under her quarter. During each weather yaw of

the ship, the boat pulls up under the quarter by means of a long bow line previously rigged and passengers can climb up cargo nets hung for this purpose from the quarter boom, or ship's side. As the ship yaws back, the boat drops back on the painter and awaits the next lee. Oil may easily be used from forward. The engines should be kept running and used as necessary.

Another method is for the boat to come under the crane, from which a cargo net is hung. As the boat comes under the crane, the net is lowered and seized by the passenger who is then swung aboard. This method is applicable underway in a heavy sea. Where so equipped, the aeroplane whip with its fast hoisting speed, should be used.

Another use of the cargo net is found in the embarkation of a large number of people at sea from the ship to a number of boats. Cargo nets are hung over the side sufficient to reach into the boats. The boats come alongside and are held there while the foot of the cargo nets are hauled into the boat and held there during embarkation. The passengers, who are already hanging on the nets then drop into the boat.

Passengers may in like manner be transferred from a boat to the ship, but care must be taken in heavy weather that the foot of the cargo net is secured inside the boat to prevent passengers from falling between the boat and the ship and being crushed.

In case of an emergency, such as recovering a number of people struggling in the water, cargo nets hung over the side of the ship may be used to expedite their recovery. This method was used successfully during the World War. There is no record of the loss of any man who had once grasped the cargo net. The survivor always gets aboard.

Towing.

In towing, the stern of the boat should be kept well down by shifting weight aft if necessary. This keeps the propeller well immersed and gives it a good hold on the water. Since the towing posts are so far aft in a power boat, the rudder is "bound," and in towing or pulling a grounded boat off the beach, with the wind from ahead to abeam, vigilance must be exercised that the boat does not drift broadside to while straining at the

towline. Securing the tow rope on the weather quarter or to some place just abaft amidships on the weather side will assist steering.

A tow should be approached slowly from astern and at a sharp angle to the heading of the tow. As the towing boat ranges alongside, the towing line is passed to the tow and is held at a short scope as the towing vessel takes the strain. The tow line is then paid out gradually to the desired scope as the strain is increased.

Take care the towing line does not foul the screw.

Securing Boats.

Boats are ordinarily secured at the booms, bows to guest warps and sterns to a boat securing line which leads from the end of the boom well aft to the ship's side. This assists in holding the boats apart and in keeping them parallel to the ship. Sufficient slack should be allowed for roll and pitch.

In heavy weather, the boom may roll dangerously, making it impractical to secure boats here. They may in this situation be secured in tandem from astern for the duration of the blow. Always use fenders.

Boats of the Merchant Service.

Requirements.

The 1929 Convention for Safety of Life at Sea. Numerous marine disasters in the recent past involving the ships of various nations brought about a universal demand for the better safeguarding of life and property at sea.

Up to 1929, merchant vessels were operating under the requirements of "The International Marine Conference of 1889." During this interval these requirements had become inadequate and did not provide the maximum safety possible in view of the improvements made in the equipment for safety of life at sea and considering the increased size and speed of modern steam vessels.

In 1914 a scheduled conference to meet this deficiency was deferred on account of the Great War.

The final result was a conference of the maritime nations held at London in 1929, which drew up regulations designed to pro-

vide increased safety. All the participating nations have subscribed to the 1929 convention and have issued regulations requiring their respective vessels to comply with it. These regulations are made and administered by the Bureau of Marine Inspection and Navigation of the Department of Commerce for the United States and for British vessels by the Board of Trade.

Requisites of Life Boats. The boats of merchant vessels are intended for saving life in circumstances of emergency, when they must be handled by a small number of men and usually under conditions of more than ordinary difficulty. It is therefore as important for them to be light and handy as to be roomy and seaworthy. The boats of men-of-war are used for a great variety of purposes, of which life saving is by no means the first, and in design are necessarily a compromise between conflicting demands.

Merchant steam vessels, and especially passenger steamers are required by law to carry a number of life boats proportioned to the size of the vessel, and the maximum total personnel which they are authorized to carry. Moreover, the law prescribes with much detail the character of the boats and the facilities which shall be provided for their stowage and handling. These facilities are directed toward getting the passengers safely away from the ship in case of necessity and ensuring their safety so long as they may be obliged to remain in the boats. Thus the question of LOWERING the boats and getting them clear of the ship receives vastly more attention than the hoisting of them. In the matter of stowage, also, questions of convenience must be sacrificed whenever necessary for quick and safe handling in an emergency.

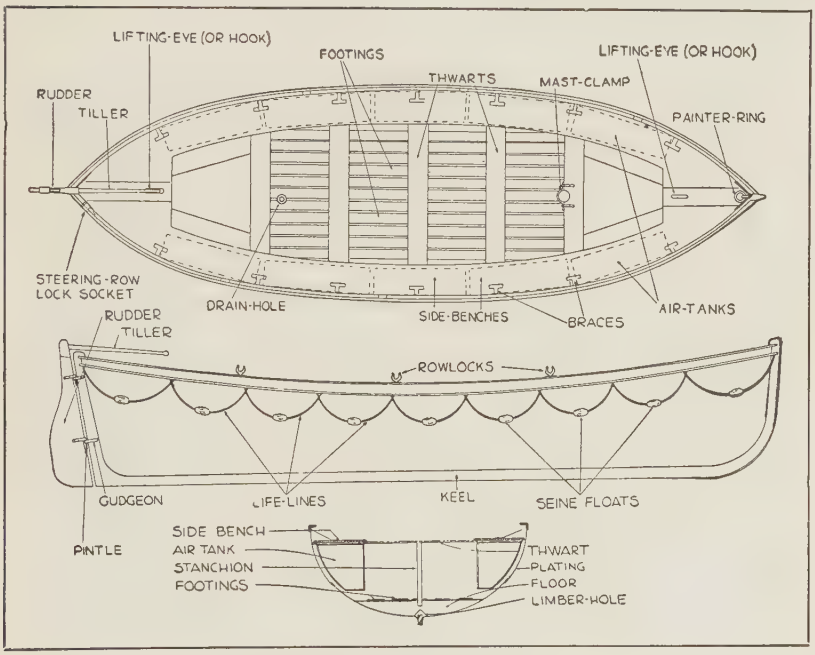
Description of Types.

General Description. The usual modern life boat is a so-called double-ender of the whale boat type (Plate **79**). These boats are of both wooden and metallic construction, but metallic boats are usually preferred for the reason that they will not burn, and that they resist the many changes of heat and moisture of warmer climates, to which they are subjected, without drying out and deteriorating.

The life boats are usually designed to be propelled by oars or sails, but a large number of ships are now equipped with

motor propelled life boats (Plate **82**). Those life boats having a capacity of up to 60 persons may be equipped with hand operated gear instead of oars, while on ocean or coastwise vessels those life boats having greater capacity must be either hand or motor propelled. This law is effective on all new construction and all replacement on existing vessels.

Plate No. 79



METALLIC LIFE BOAT.

Classification of and Regulations for Life Boats.

Note.—Detailed requirements for life boats may be found in a publication issued by the Department of Commerce, Bureau of Marine Inspection and Navigation: "General Rules and Regulations prescribed by the Board of Supervising Inspectors."

Strict laws have been enacted, specifying the type, number and equipment of life boats which must be carried by all passenger vessels sailing from or touching at our ports. As to construction, life boats are classified as follows:

Class I. Rigid-sided boats.
Class II. Partially Collapsible-sided boats.

These classes are further sub-divided according to variations of construction into I A, I B, I C, and II A, II B and II C, and are required to have air tank buoyancy proportioned to the number of passengers they are designed to carry. The required buoyancy must be acquired by non-corrosive metal tanks along the sides and in both ends. Fifty per cent of the buoyancy must be on the side and 50 per cent in the bow and stern.

Recent legislation requires that all boats for new construction and replacements on existing vessels conform to the requirements of a Class I life boat. Class I A (Plate **79**) may be regarded as the standard life boat of the merchant service. It may be either of wood or metal and if of wood, of either Carvel or Clinker construction.

All life boats are constructed in accordance with rigid specifications and must be of sufficient strength to enable them to be safely lowered into the water when loaded with their full complement of persons and equipment.

The requirements as to construction of the three groups of Class I life boats are as follows:

Class I A—Rigid sides. (Open boat. Internal buoyancy only.) (Plates **79, 80, 81**).

Class I B—Rigid sides. (Open boat. Internal and External buoyancy).

Class I C—Pontoon. Well deck; fixed watertight bulwarks.

The number of persons that may be carried in a Class I A boat is found theoretically by allowing ten cubic feet of internal volume of the boat to each person. The practical way of determining this is to decide upon a safe minimum of freeboard for the service required, and then, to load to this line with men distributed as they would be distributed in actual service. Nine inches is a fair allowance of freeboard for life boats up to 30 feet in length and twelve inches for larger boats.

The cubical contents of life boats is determined in accordance with prescribed rules and must, together with the carrying capacity, be plainly marked on each boat. No boat for use on ocean

STEWARD LIFE BOATS, DAVITS AND LOWERING DRUM.

steam vessels shall be of less than 180 cubic feet capacity (18 persons capacity).

The law requires that metallic boats have one and one-half cubic feet of air tank capacity for each person allowed in addition to the amount necessary to float the boat (including its equipment) when filled with water. Wooden boats must have one cubic foot of air tank capacity per person allowed.

All life boats must be equipped with a life line or grab line properly secured, the length of each side, festooned in bights, with a seine float in each bight.

Metallic life boats must be equipped with automatic plugs and wooden boats must have either an automatic plug or two plugs secured with chains to each drain hole.

All life boats must be equipped for using a steering oar.

The law specifies the minimum equipment which must be carried by each life boat. This list is very complete and provides for provisions, navigational equipment and signaling apparatus.

Steward "Deadrise" Boat.—Class IA (Plate **80**). This is a metallic boat, manufactured by the Steward David and Equipment Corporation. The flat floor of this design makes it possible to carry the air tanks lower than in a boat with a round bilge and admits of lowering the thwarts and thus the center of gravity of the loaded boat. The elimination of many of the curves which are involved in the conventional full-bilge design reduces the number of plates and therefore the number of seams and rivets; and with these, the danger of leakage. Experience appears to justify the further and more important claim that the design has advantages in the matter of seaworthiness.

Lundin Boat.—Class IA. Plate **81** shows the LUNDIN decked life boat, with collapsible sides, capable of carrying 60 passengers with ample reserve buoyancy. Although this boat is of the PONTOON type it has rigid sides and internal buoyancy and has been given the classification of IA. The boat is decked throughout its length and fitted with trunks for self-bailing. It will be seen that the collapsible feature of the bulwarks adds greatly to the compactness of stowage. The hinged weather boards fold down upon the deck when not needed, but can be quickly raised when the boat is to be used, and lock securely into their places. The space below the deck is divided into water-tight compartments which are in reality air tanks placed

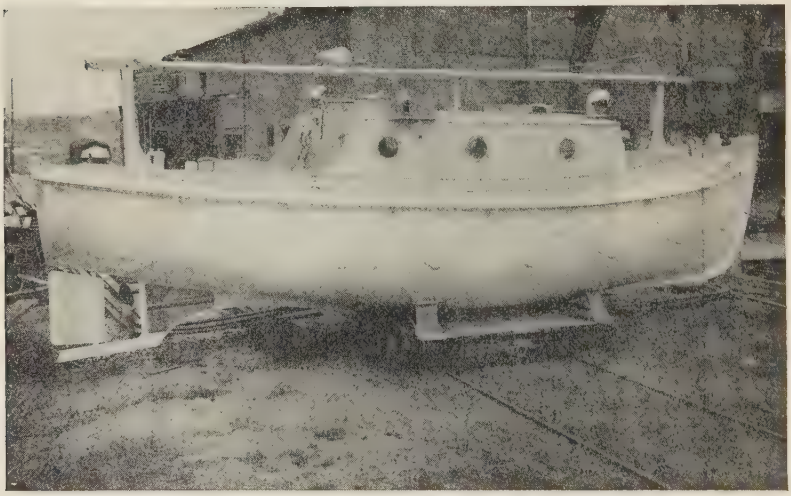
LUNDIN DECKED BOAT.

in the very bottom of the boat. This type of boat, in which the buoyancy is secured by a water-tight subdivision of the hull of the boat, and not by the addition of air tanks, is called the PONTOON type.

It is claimed that the characteristic spoon-shaped bow and stern of the LUNDIN boat add much to its seaworthiness.

Motor-Propelled Life Boats. (Plate **82**). Proposed laws pertaining to the carrying of motor life boats are quoted below.

Plate No. 82



WELIN MOTOR LIFE BOAT.

Some of the latest liners have all motor-propelled life boats, some of which weigh as much as 18 tons. All passenger vessels certificated for ocean service shall be provided, as part of their regular equipment, with motor-propelled life boats, as follows:

(*a*) Ships of more than 2,500 gross tons, plying routes on which they are at any point more than 200 miles offshore, shall be provided with one motor-propelled life boat.

(*b*) Ships on which the number of life boats carried is more than thirteen shall be provided with one motor-propelled life boat.

(*c*) Where the number of life boats carried is more than nineteen, two shall be motor-propelled life boats.

(*d*) Any life boat certified to carry one hundred or more persons shall, if not one of the motor life boats required above, be motor-propelled or fitted with a hand operated propeller. (Plate **83**, Fig. 1). (Effective on existing vessels November 7, 1937, and on new vessels immediately).

(*e*) Motor-propelled life boats shall comply with the requirements for a life boat of Class I; and the volume of the internal buoyancy, and, where fitted, the external buoyancy, shall be increased in sufficient proportion to compensate for the difference between the weight of the motor, the searchlight, and the radio telegraph installation and their accessories, and the weight of the additional persons which the boat could accommodate if the motor, searchlight, and the radio telegraph installation and their accessories were removed.

The present law requires that all motor life boats shall be fitted with a radio installation and a searchlight. (Plate **82**).

The radio installation shall be of a type capable of transmitting signals between the life boat and ship on the international calling and distress frequency, and a receiving equipment capable of receiving such signals. The minimum required range shall be 50 miles in daytime under normal conditions. The power supply shall be capable of operating this equipment for a continuous period of at least 6 hours.

Where the power is derived from one source for both the radio and the searchlight, it shall be ample to provide for the efficient working of both appliances.

Hand-Operated Boats. All boats not motor propelled, of over 60 persons capacity, must be equipped with hand-operating gear. Plate **83**, Fig. 1, shows the essential features of an approved boat of this type.

The Allen Manual Motor installed as shown consists essentially of two fore and aft rods equipped with handles which, when pulled forward and aft by the passengers, turn the propeller through attached wire cables running over drums connected to the propeller shaft.

Direction—forward, stop and back is controlled by a shifting lever operated by the coxswain.

To operate, all that is required of the ship-wrecked passenger, unskilled in oarsmanship, is that he pull alternately forward and aft. There is room for sixteen men on this installation.

FIG. 1.
ALLEN HAND-OPERATED LIFE BOAT.

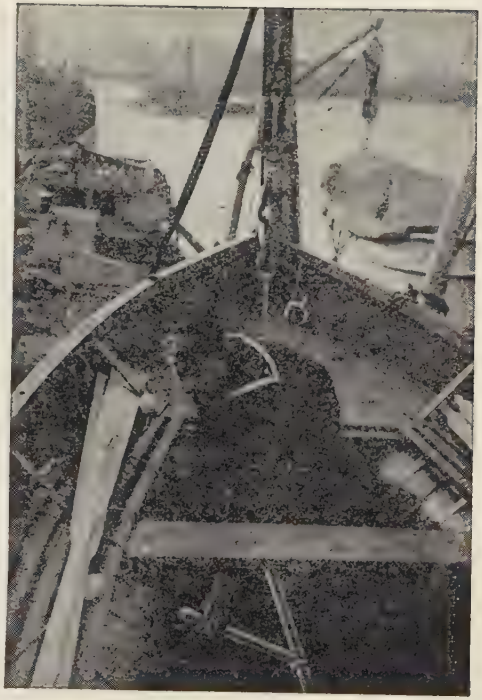


FIG. 2.
BOAT RELEASING GEAR.

Life Rafts. The law requires that passenger vessels be equipped with a sufficient number of life boats to accommodate seventy-five per cent of the passengers and that the remaining twenty-five per cent be provided for with life rafts of approved type.

One type of float consists of copper air tanks incased in "balsa" wood, a strong wood lighter than cork, and covered with heavy canvas.

Another type is the elliptical cylinder made of waterproofed balsa wood, covered with canvas and provided with a net extending some three and one-half feet below the water to provide a platform for the passengers to stand on.

Stowage of Boats.

Merchant vessels usually carry their boats inboard under davits or chocks, with gripes (lashings), holding them securely and with canvas covers to protect them from the weather (Plates **84**, **85**). All the boats must be stowed in such a manner that they can be launched in the shortest possible time and under unfavorable conditions of list and trim. The law requires that boats be capable of being lowered with a fifteen degree list on the ship.

Where manila falls are used, the tackles are kept hooked and hauled taut with the falls coiled down in a container or on a reel and ready for immediate use. The falls must be protected from ice. The best way to carry the falls is on a reel or drum. To lower the boat, the falls are led to bitts (called "crucifixes") placed in the deck. Two men, especially trained, are stationed at each fall to lower away.

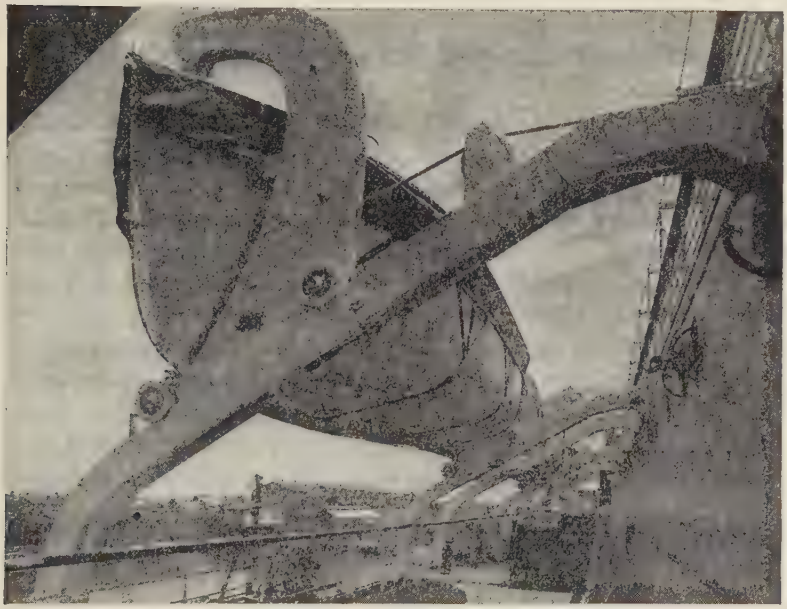
Where wire falls are used, the falls are led to drums on the same shaft of an electric winch and the lowering is controlled by a brake. This makes it possible for one man to lower the boat, keeping it under perfect control, and insures both falls being lowered together. A further advantage of this arrangement is the smoothness with which the boat can be lowered from a drum as contrasted with the jerkiness and consequent large increased strain which often accompanies the lowering of a boat by easing the fall around a bitt or cleat

BOAT STOWAGE OF A MODERN SHIP. QUADRANTAL DAVITS IN FOREGROUND, GRAVITY DAVITS IN BACKGROUND.

In all cases where the boats rest in chocks, it is important to avoid the necessity of lifting the boats to clear them from the chocks. A common arrangement is one in which chocks are used on the inboard side only. (Plate **90**, Figs. 2, 3).

The gripes by which the boat is held down to the chocks are secured by lashings but can be released instantly by tripping a

Plate No. 85



STOWAGE OF BOATS USING MACLACHLAN GRAVITY DAVITS.

slip-hook, such as is always interposed between the deck lashing and the clamp on the gunwale of the boat. (Plates **84, 85.**)

The law requires that life boat decks be kept clear of freight or obstructions which would interfere with the launching of the boats, and ladders must be provided at each boat for embarkation.

The law further requires that where boats are thirty feet or more from the waterline, illumination must be furnished and where the boats are stowed 100 feet or more from the bridge, a loud speaker system must be provided to enable the officer on the bridge to broadcast orders to the boats. On passenger ves-

sels, carrying boats more than 20 feet above the water line, wire falls and mechanical means for lowering must be provided.

An emergency life boat, one on each side, must be carried, rigged out, with a sea painter attached, ready for instant use.

Davits and Lowering Devices.

In addition to the old style curved iron davit, which is still used to some extent, there are several patented systems of boat control. These mechanical davits are rapidly replacing the old style davit on merchant ships and are required on all new passenger vessels.

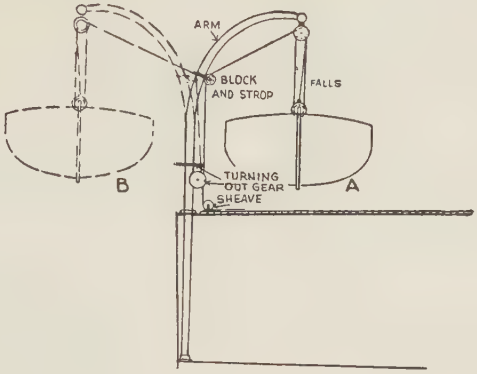
Davits are of three distinct types: the gravity, quadrantal, and radial or round bar. (Plate **86,** Fig. 1, Fig. 2, Fig. 3.)

With the *gravity type davits,* the life boat is carried on two cradles, mounted on rollers, which move over two parallel tracks at right angles to the vessel's side. In operation, a lever controlling a brake is raised which permits the life boat and the entire assembly to roll down the tracks by gravity, stopping with the life boat suspended over the side and at the embarkation deck. A tricing line may be so attached as to gripe the boat in alongside of this deck at the proper level. Raising the lever again permits the boat to continue down, until it reaches the water. This type is coming into favor for the following reasons:

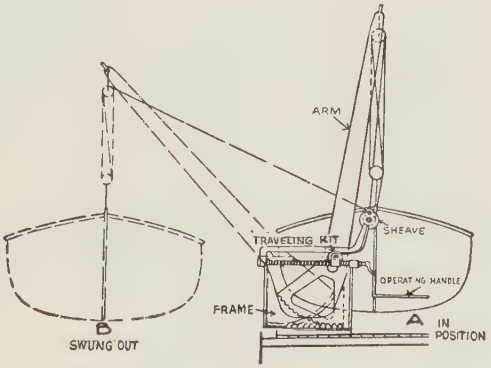
1. One man only is required for the complete operation of lowering a boat safely.
2. Single wire falls may be rigged which, coming off the same winch drum, insure even lowering of both ends.
3. The fixed declivity of the track insures launching at an angle of list much greater than the minimum required list—15°.
4. The boat is kept in close to the embarkation deck at all angles of list.
5. Boats being stowed six to seven feet above the deck gives increased deck space.

Quadrantal Davits.

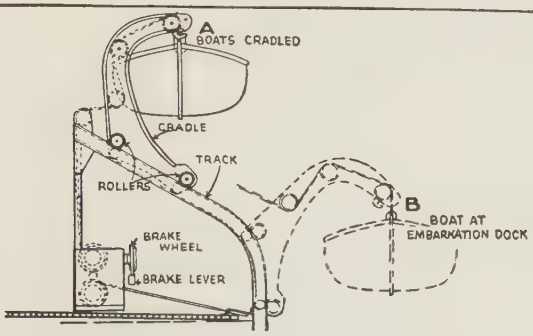
With the quadrantal type davits (Plates **84** and **86**), the life boat is carried on chocks under the davits. The davits themselves stand upright, with the tops curved in toward each other so that



ROUND BAR OR RADIAL DAVIT. FIG. 3.



QUADRANTAL DAVIT. FIG. 2.



GRAVITY DAVIT. FIG. 1.

TYPES OF BOAT DAVITS.

the ends come directly above the hoisting hooks of the life boat. In operation the boat is raised when the hand crank is turned until clear of the chocks, and then the davit, which is pivoted near the foot, so that it will turn in an arc at right angles to the vessel's side, is rotated outboard by means of a crank operating a worm gear, so that the boat is suspended over the side. It is then lowered to the water in the usual manner by its falls. This is a successful and common type on merchant vessels.

Radial or Round Bar Davits.

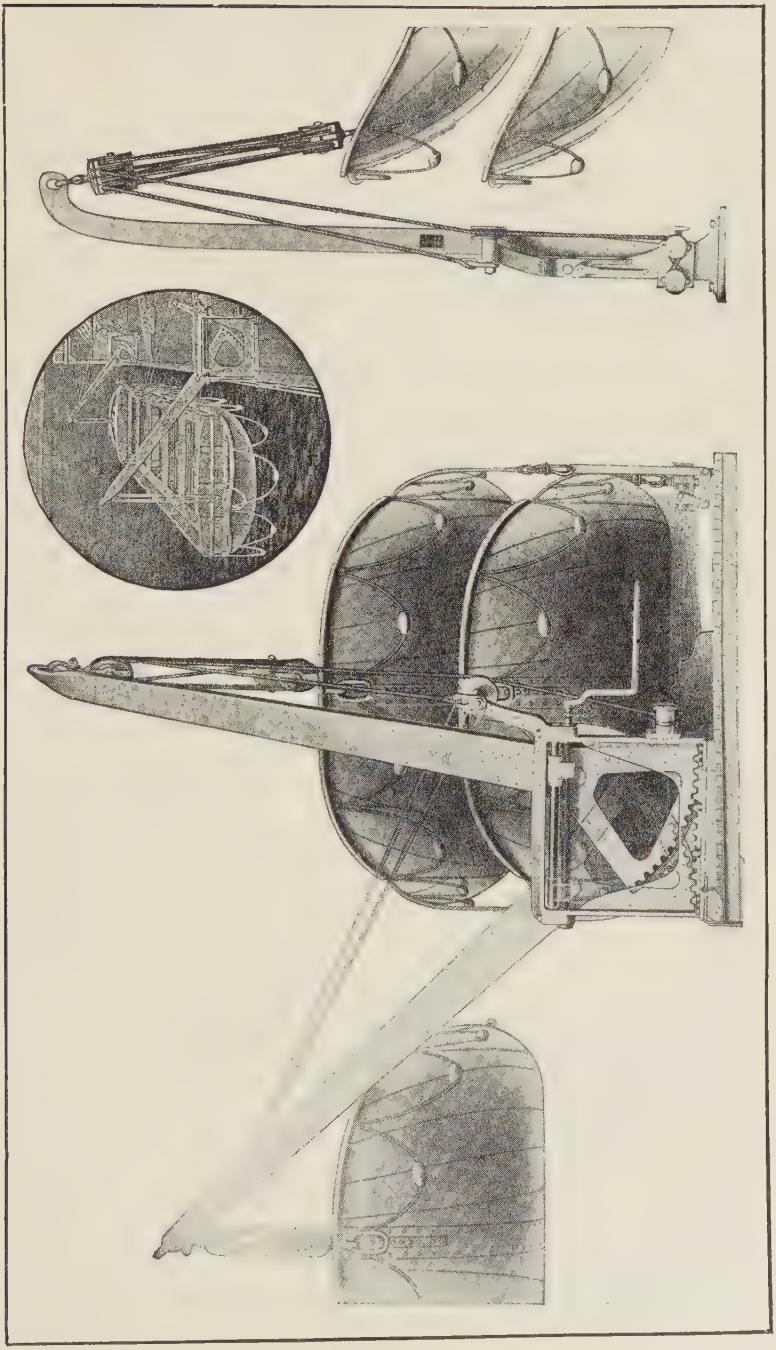
With the radial or round bar type davits, the life boat is carried on chocks, rigged under davits, which may be turned around so that the top describes a circle. In operation, the boat is raised from the chocks, the davits are both turned aft until the bow of the boat clears the forward davit. The forward davit is then turned out so that the bow swings out, and the same procedure follows with the after davit, so that the boat is suspended over the side. It is then lowered to the water by its falls. This type of davit must always be guyed. While simple in principle, its principle disadvantage is that it takes about six or more men to work it and rigging the boat out against a heavy list may be very difficult. On some ships this difficulty is partially overcome by the use of mechanical turning-out gear.

Releasing Gear.

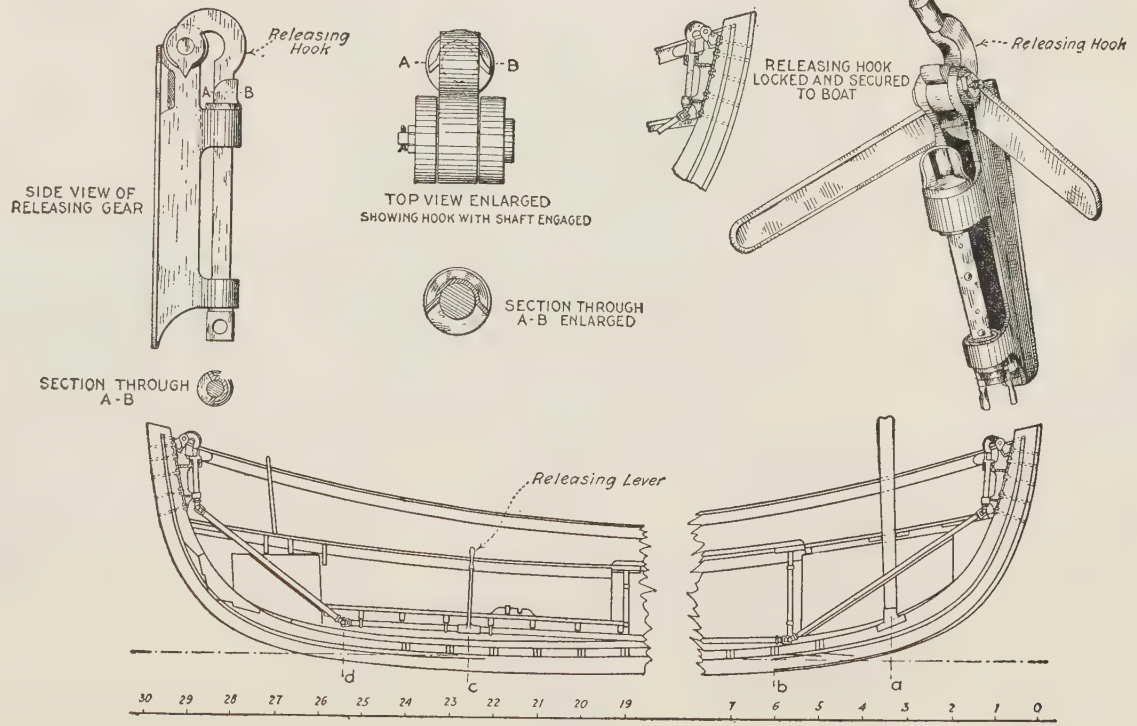
Purpose. Releasing gear is required on life boats. Its purpose is to permit releasing both falls from the boat simultaneously, by one man, either before the boat is waterborne or immediately thereafter and while under a towing strain.

Types. Types in use are the *Rottmer,* (Plate **88**) and *Steward* (Plates **83, 89**). These consist of two releasing hooks in each end of the boat to which the falls are attached. These releasing hooks are hinged on pins and held engaged by a locking device. A jointed shaft running the length of the boat is connected to both locking devices. Upon throwing a lever attached to this shaft, the hooks are capsized and the boat released.

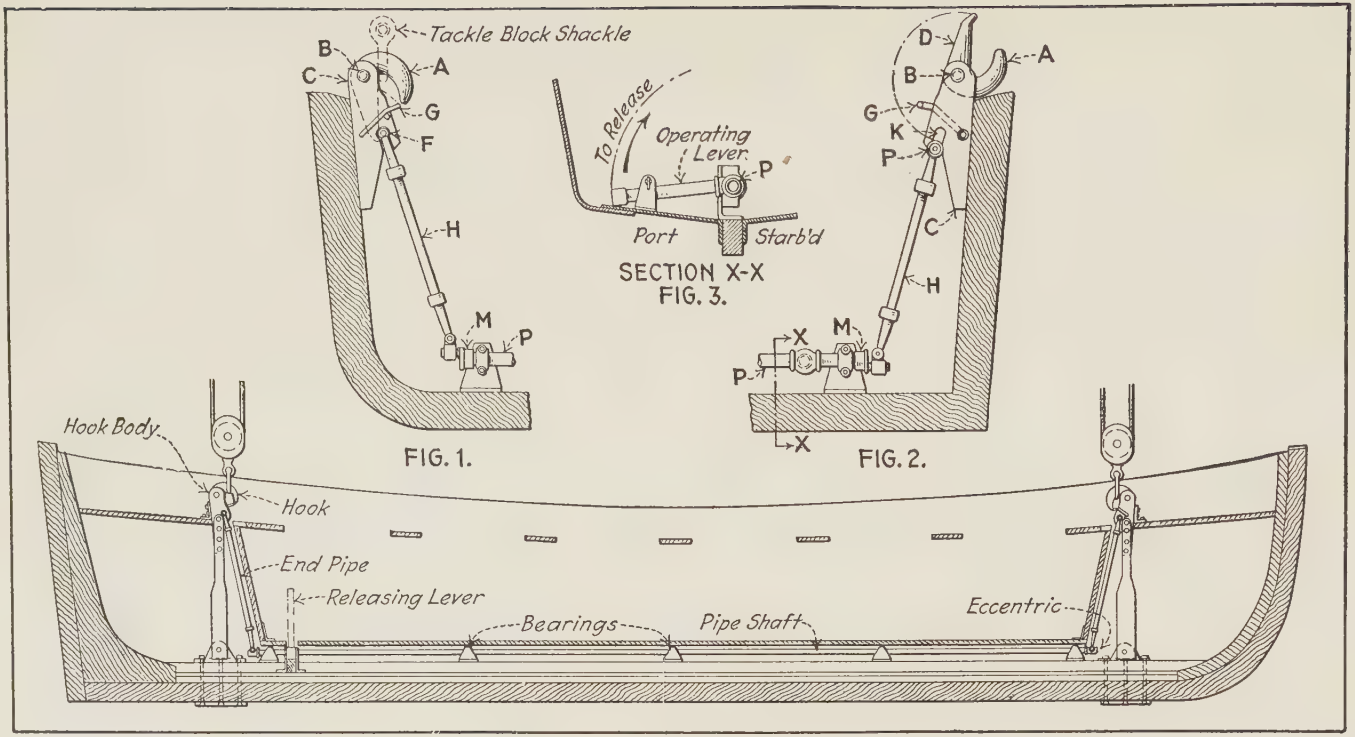
Another common type is the *Mills* chain-pull type. (See Plate **90,** Fig. 1). The gear release handle is conveniently located on deck at the after end of the boat and when pulled, trigger



WELIN PATENT DAVIT.



ROTTMER DETACHING GEAR.



STEWARD RELEASING GEAR.

hooks with ball weights to which the boat falls are made fast, drop and the boat is free, fore and aft. The boat must be waterborne before the releasing gear can work. When being lowered the weight of the boat and its load is, for safety's sake, directly opposed to releasing.

Lowering a Life Boat.

To launch a pulling life boat and get it away:

Muster the crew; see that they all have on properly adjusted life preservers; remove the boat cover and strongback; hang the ladder over the side; have one bow and one stroke oarsman lay in the boat and see that the plug is in or that the automatic plug is free, and that the life lines are clear; have the painter led well forward outboard of the davits; let go all gripes and the boat chocks; remove the reel covers; raise the boat clear of the chocks, using half the crew on the forward fall and the other half on the after fall, and belay the falls; slack davit guys and swing the boat out; set the davit guys taut and belay; have stroke oarsman ship rudder or place steering oar in readiness; place all crew in boat except two men at each fall, one to see that falls are kept clear and one to lower; lower away on both falls evenly; have bow and stroke oarsmen ready with boat hooks to fend off from vessel's side; trip releasing gear as soon as the boat is waterborne; have remainder of boat's crew come aboard by ladder; take passengers aboard, either at embarkation deck or after boat is in water, seeing that they all have on properly adjusted life preservers; shove boat's bow off and have crew commence rowing, giving them the following orders: "Out oars"; "Let go the painter"; "Stand by your oars"; "Give way together."

If the boat is under radial davits, guy the boat out as described above; if under quadrantal davits, crank the boat out; if under gravity davits, place one hand on lever, raising it slowly, keeping the boat well under control, and permit the boat to roll down the runway, controlling it by frapping lines.

To Launch a Boat in a Heavy Seaway.

The vessel should first be hove to in such a position as will render it most lacking in motion and which will offer as good a lee as possible for the boat to be launched. Some vessels are

MILLS RELEASING GEAR INSTALLED IN LIFE BOAT

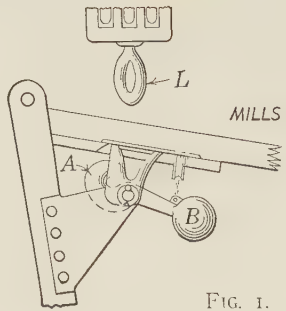
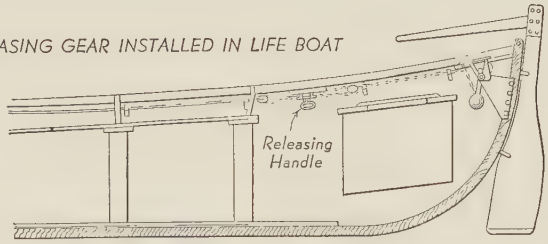


FIG. 1.



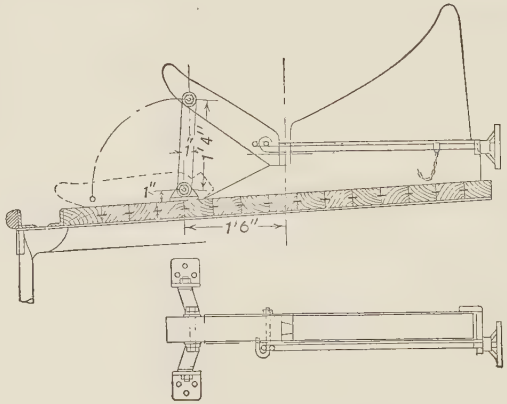


FIG. 2.

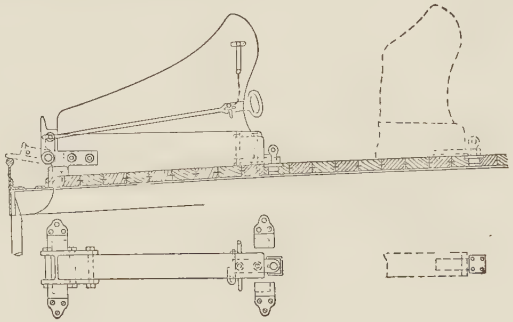


FIG. 3.

better in the trough, some with the sea on the bow, and some with a quartering sea. A boat may be launched with care by a well-drilled crew under adverse conditions. If the boat is not fitted with skates, mattresses should be slung up and down the side. Prior to lowering, a barrel of oil should be broken over the vessel's side so that the oil will keep spreading. If the vessel is rolling, the boat itself should be kept from swinging as much as possible by frapping lines until ready to lower. If the vessel is pitching, the boat should be kept from swaying by keeping the painter taut, the frapping lines should be let go, the boat should be lowered away smartly, the releasing gear should be tripped as soon as the boat is waterborne, and the boat sheered off immediately from the vessel's side by using the steering oar and sea painter.

Manning the Life Boat.

Life boat drills must be held once a week, weather conditions permitting, during which the boats are swung out ready for lowering. At least once in three months, every member of the crew of a passenger vessel except females must participate in a drill during which he actually pulls an oar in a boat.

A licensed deck officer or able seaman who is a certificated life boat man must be in charge of each boat and depending on the capacity of the boat, a number of certificated life boat men are assigned as crew, never less than two and need not be more than five.

A rigid examination which includes operation of life boats and boat lowering gear must be passed before a man may obtain a certificate as a "certificated life boat man."

The motor and hand operated gear of each life boat must be operated under service conditions ahead and astern for a period of not less than five minutes once a week, in order that it may be ready for service at any time.

V.

Sail Boats.

Rig of Ship's Boats for Sailing.

Ship's boats are working boats and not designed for sailing. They are sturdy, have a good beam and shallow draft. They

must admit of carrying passengers and stores, of coming alongside safely, yet be light enough to hook on and hoist in a seaway.

When rigged for sailing, these boats must depend for their stability on their wide beam as the practical considerations mentioned preclude a heavy outside keel or the addition of inside ballast. These characteristics limit the sail-carrying ability of ship's boats and the resulting rig is usually a combination of small easily handled sails with a low center of effort. These rigs are, of course, much less efficient than the tall narrow rigs usually carried by yachts having deep heavy fin keels.

The spars and sails of a man-of-war boat must be light and easily handled, and must stow compactly when the boat is under oars. The fewer, shorter, and lighter the spars, the better. Masts, especially, should be short and light, easily stepped by a few men, and call for little support from shrouds and stays. Bowsprits and booms are particularly inconvenient, as are also the bumpkins which in some rigs project beyond the stern. A rig which entails danger of capsizing is, of course, objectionable.

Of the rigs considered suitable for man-of-war boats, the most common are the following:

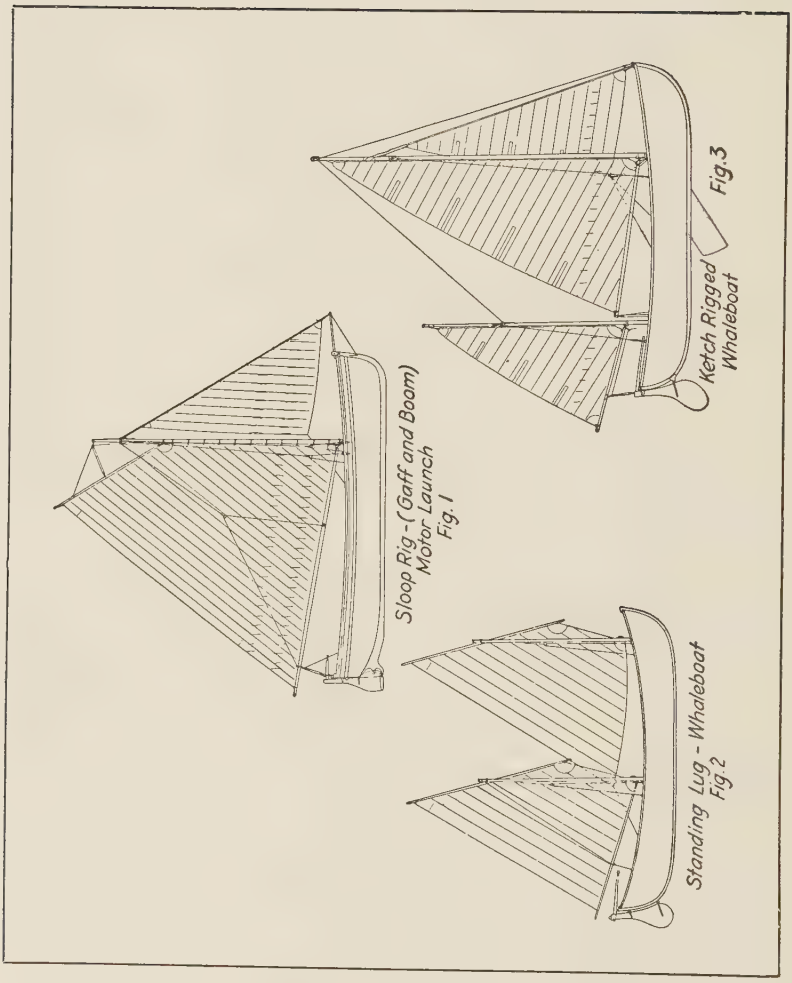
1. **A Gaff and Boom Mainsail with Bowsprit and Jib** is the standard rig of the 36- and 40-ft. United States Navy motor launches. (Plate **91,** Fig. 1.) This rig needs little comment. It is the familiar sloop rig, having a good spread of canvas and a low center of effort. The comparatively short mast is easily handled by the crew and no other gear other than that of the rig itself is required for this operation.

As the boat has very little keel and has a shallow draft, it makes considerable leeway when on the wind, and because of its long, straight keel, does not tack readily in a choppy sea.

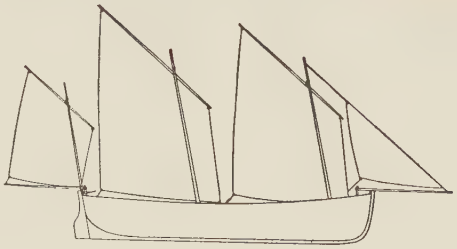
2. **The Standing-lug** is used in the United States Navy for the whaleboat and the 24-ft. motor launch. (Plate **91,** Fig. 2.)

The standing-lug takes its name from the fact that the tacks of the sails "stand," being secured to the mast, and so do not have to be dipped around the mast in tacking. The rig is safe and convenient to handle, but lacks the driving power of the dipping-lug.

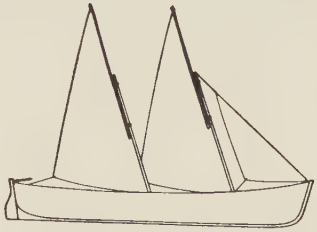
The details of rigging for lug sails vary considerably, but the yard is always attached to the mast by a sliding parrel, or



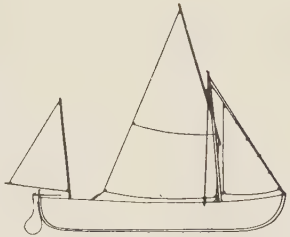
RIG OF BOATS FOR SAILING (U. S. NAVY).



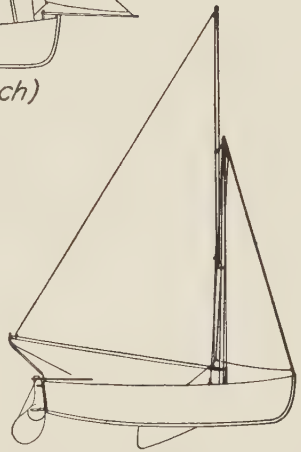
Balance Lug (French)
Fig.1



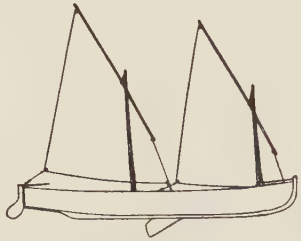
Sliding Gunter (French)
Fig. 2



Standing Lug Ketch
(British)
Fig.3



14' Sailing Dinghy (British)
Fig.4



Dipping Lug (British)
Fig.5

RIG OF SHIP BOATS FOR SAILING, BRITISH AND FRENCH.

traveler, moving freely up and down. The halliards are usually rove through sheaves in the mastheads, from aft forward, and lead down to cleats on the forward side of the mast where they secure. This prevents the halliard fouling the yard when it is dipped. Shrouds tend aft from mastheads and secure with shroud whips to the gunwale.

The foresail is loose-footed while the mainsail is attached to a main boom which has a topping lift to spill the wind from the mainsail when jibing in a fresh breeze. It is not necessary that the yard be dipped for each tack, but the sail sets better when this is done.

3. **The Dipping-lug.** (Plate **92,** Figs. 1, 5.) The dipping-lug and the combination of the dipping-lug and standing-lug are used in the boats of some foreign navies and in many fishing vessels. It takes its name from the fact that the tack of the sail is secured forward of the mast and must be "dipped" around abaft the mast in tacking. In addition, the yards must be dipped for each tack. It is commonly regarded as better than the standing-lug for speed and weatherliness, but because the sail may be caught aback if the tack or yard is not dipped promptly it is hard to handle and even dangerous with any other but a well-drilled crew.

The details of rigging are similar to those for the standing-lug. If no shrouds are used, the halliards are set up to windward tending aft and help to support the mast. A convenient way to fit the halliards is to use a pendant with a single block at the end through which a whip is rove.

The dipping-lug involves very little gear, and is quickly and easily rigged. The forward part of the foresail acts as a jib, but with greater pull and smaller leverage; and the absence of bowsprit is an advantage in going alongside or when plunging into a head sea.

The halliards of a dipping-lug are bent one-third of the length of the yardarm from the forward end. The tack is usually hooked to the stem, except in sailing free, when it is shifted to a hook on the weather bow. The most serious danger connected with the dipping-lug rig arises from the fact that if the sail gets aback, it binds against the mast and cannot be lowered. In this situation, in a fresh breeze, there is serious danger of capsizing. It is a good plan to always secure the tack with a "slip-

hitch," which admits of casting it off instantly in an emergency, which causes the sail to spill immediately.

4. **U. S. Navy Ketch Rigged Whaleboat.** (See Plate **91,** Fig. 3.) This boat is carried by certain ships of the Navy and is used exclusively for recreation. It is very similar to the Navy whaleboat, is fitted with a centerboard and a ketch rig, and has comparatively high, narrow, jib-headed sails.

This boat, with its centerboard and high rig, shows the modern trend of all navies to provide ships with boats especially designed for sailing. (Plate **91,** Fig. 3; Plate **92,** Figs. 4, 5.)

The masts are supported fore and aft by a forestay, and a main backstay. Shrouds tending aft from the main and mizzen complete the support for the masts. All standing rigging is of wire.

The sails are attached to the booms and mast by means of tracks and slides. Single halliards rove through sheaves in the mastheads lead down the forward side of the masts, where they secure to cleats.

The boat is comparatively easy to rig and unrig, the masts being so hinged that they may be laid down in the boat; the main, aft, and the mizzen, forward.

The boat is handy, seaworthy, well balanced and fast on any point of sailing. It will sail from five to four and one-half points on the wind. Its centerboard allows but little **leeway.**

As the boat is light, has a comparatively high center of effort and has a low freeboard, care must be taken that sufficient crew be carried to hold down the weather rail. The crew must be prepared to shift their weights when the boat tacks or wears.

The boat pulls ten oars and is an excellent pulling boat.

5. **The Sliding Gunter.** (Plate **92,** Fig. 2.) This rig was formerly used in the United States Navy for cutters, whaleboats and gigs. The rig was discarded because the spars were awkward to handle and stow, inconvenient to carry in the boat when under oars, and impossible to do so when oars were used in rough water. It is a safe and convenient rig in that sail may be reduced in an instant by letting go the halliards, which house the topmasts. If the rig is fitted with booms and topping lifts, the sails may be brailed up at the same time. The rig is still used in the French Navy.

6. **The Balanced or French Lug.** (Plate **92,** Fig. 1.) The French lug is a compromise between the standing and dipping-lug and combines many of its advantages. It may, in fact, be used either as a standing or a dipping-lug, the forward yardarm being dipped in either case. If the yard is not dipped, the yard lies to windward of the mast on one tack and to leeward on the other.

This rig is used in the French Navy for cutters.

VI.

Handling Boats Under Sail.

Terms Used.

The direction of the wind is that from which it blows. To *windward* is into the wind; to *leeward* is down the wind. A *lee shore* is the shore to leeward. The *weather* side is that side exposed to the wind; the *lee side* is the opposite side. Naturally a boat heels away from the wind, so that the lee side is *down* and the weather side *up*. When the rudder is amidships the tiller or helm * is also. The coxswain may put his tiller up to

* Note.—While the terms "helm" and "tiller" have been officially banned in connection with modern steamers, they are still applicable to sail boats and will be used here in accordance with original practice.

windward and have *weather helm,* or if he puts it down he has *lee helm.* When a boat turns her head into the wind, as if she were going to tack, she is said to *luff.* The opposite of this is *bearing away.*

When sailing with the wind on one side, a puff of wind may strike the sails causing the boat to heel and possibly capsize. To prevent this, the coxswain may luff by putting his helm down until she turns into the wind; the sails then cease to *draw,* and the boat comes back to an upright position.

It may be necessary in a heavy squall to let the sheets go; therefore, in a small boat *never belay the sheets.*

When a sheet is hauled in and the boom or foot of the sail is nearly fore and aft, the sheets are said to be *hauled aft.* In *setting the jib aback* or *backing the foresail,* the weather sheets are *flattened aft.* This may be required to give more turning

effect in tacking and is also done in *heaving to.* To bring the sails more nearly parallel to the center line of the boat they are *trimmed in*; the opposite is *easing off or starting the sheets.*

A boat cannot sail directly into the *eye of the wind,* but sails depending on the boat and rig, at an angle of from four to six points from it. She must thus make a zigzag course upwind on *tacks,* or *boards.* This process is called *beating to windward.* She is said to be sailing *close-hauled* or *on the wind* on each of these tacks.

A sailboat is said to be on the *starboard tack* when the wind is coming over the starboard side, and the *port tack* when the wind is coming over the port side. When a boat is not sailing as close to the wind as possible with advantage, she is said to be *sailing free.* When the true wind is within two points on either quarter, she is said to be *running* before the wind. If, when sailing free, the wind is still forward of the beam, she is said to be on a *close reach*; if the wind is from abaft the beam she is said to be on a *broad reach.* The *apparent wind* is the wind striking the sails which is generated by a combination of the ship's speed through the water and the *true wind.* In obeying the Rules of the Road the prevailing or true wind fixes the respective obligations of sailing vessels.

Tacking is bringing the boat on the opposite tack, head through the wind. *Wearing* consists in turning the boat from one tack to the other tack, stern through the wind. During this procedure, as the wind comes aft and the sails are trimmed flat, the boom is carefully and intentionally allowed to swing to the opposite side. The boom is then said to have been "*jibed*" over. Should the boat be sailing free and alter her course so as to bring the wind on the opposite side, carrying the stern through the wind, she has been "jibed," such as "jibing around a buoy."

Trim. To do her best under sail, a boat must be trimmed in accordance with her build and rig. To effect this condition, the trim of the boat and sails must be altered, as necessary, to meet the varying conditions of sailing.

In sailing on the wind, a properly designed and trimmed boat should carry a slight weather helm; that is to say, she should have a slight tendency to come into the wind. If too much weight is carried forward, the boat trims by the head, the stern

rises, offering less lateral resistance aft to the water. The bow being deeper, offers greater lateral resistance to the water, and in addition has the increased pressure of the bow wave on the bow. These forces form a couple tending to cause the boat to luff, which, to counteract, necessitates an excessive weather helm. Too much weight aft causes a corresponding tendency to fall off.

If the sails are too flat forward, lee helm is necessary to counteract the tendency to fall off; if too flat aft, weather helm is necessary.

In addition, as the boat heels, the forward component of the force of the wind on the sail acting on the center of effort is displaced to leeward of the keel line, which produces a leverage which tends to make the boat luff. This tendency is especially noticeable in a tall sloop rig, which endeavors to "work out from under" when struck by a sudden gust as she is making good headway close-hauled.

When running before the wind, weights should be carried aft to decrease yawing, but this may decrease the speed, if overdone.

After the boat has been underway for some time, the sail or halliards may stretch, or in wet weather, may shrink. This calls for appropriate setting up or slacking off on the halliards to correct the set of the sail.

Close-Hauled—on the Wind.

On the wind, a boat should carry a little weather helm. The sails should be kept well full, sheets not too flat, but everything drawing and the boat alive. It is a common mistake to get the sheets so flat that the boat, while pointing high, actually makes a course to leeward of that which she would make if kept away a little with sheets eased accordingly; and it is of course clear that, if kept away, her speed will be greater than when jammed up into the wind in the hope of stealing a fraction of a point. A boat of good draft with a deep keel and centerboard, and yachts designed for racing, with fin-keels ten feet below their normal water line, will lie amazingly close to the wind with little leeway. Ship's boats, however, are not constructed on yachting lines and cannot be held up in the same way. An exception to this is the Navy centerboard whaleboat, previously described. The shape of the sail when close-hauled is very important; the leech should

be almost flat, and some boats, to accomplish this, have battens which fit in pockets in the leech of the sail. A little curve or belly should be allowed in the luff. The cut of the sails, the way they are laced to the yards and booms, and the tautness of the halliards all affect the shape of the sails when drawing.

The sails being properly set, the luff of the sails are kept just short of trembling, with weather helm enough to let the helmsman "feel" that she wants to come into the wind. As the wind will vary more or less (in apparent, if not real, direction), it is necessary to be watchful and bring her up or keep her away from time to time in order that she may be always at her best. The sails should be kept fuller in rough than smooth water, as it is more important that the boat should be kept *going* so as to be always under command of the rudder. If a heavy breaking sea is seen bearing down upon her, she should be luffed to meet it and kept away again as soon as it has passed. If she loses way she becomes helpless at once. It is dangerous to be caught by a heavy sea on the beam; and, if the course to be made in rough water would bring the boat into the trough, it is the best plan to run off for a time with the sea on the quarter, then bring her up with it on the bow, and so make good the course desired without actually steering it at any time.

For a moderate squall, the boat should be luffed sufficiently to shake the sails without spilling them, thus keeping enough headway to retain control. If the wind becomes stronger, she must be luffed more decidedly and the sheets eased off. The sheets may of course be let go, and in an emergency this must be done at once, in addition to putting down the helm. For this reason it is a universal rule in boat sailing that the sheets should never be belayed or left untended in any weather.

SAILING FREE.

A boat sails her fastest on this point of sailing. The tendency to luff is strong, especially if the wind is fresh and the boat or sails are improperly trimmed. In a squall the situation is quite different from that in sailing close-hauled. Here the wind cannot be spilled by a touch of the tiller and the only prudent thing to do is to slack the sheets while luffing. In this procedure care must be taken not to jam the helm down hard for it causes

the boat to heel dangerously to leeward, and as it turns into the wind the lee quarter and rail may go under, the end of the boom trip in the water, and the boat capsize. The same thing may happen in jibing if the boat is allowed to fill away too quickly on the new tack. The force of the wind would be much reduced by running off, but the trouble with this is that, if it comes too strong, there is no recourse but to lower the sail, and the chances are that it will bind against the shrouds and refuse to come down. Moreover, there is always danger that the wind will shift in the squall, and the mainsail may jibe with dangerous force.

The gaff-headed rig has the advantage over the tall triangular rig on this point of sailing, but the gaff-headed mainsail must be tended more carefully, as the efficient angle to the apparent wind exists within narrower limits than that of the jib-headed rig. In general, in sailing free the gaff-headed rig must be trimmed closer than a jib-headed rig in order to maintain its most efficient angle. This requires close watching of the apparent wind at all times. Under-water resistance may be somewhat reduced by partially raising the centerboard, if the boat be so equipped.

The tall jib-headed rig gains power as the wind hauls forward and the low gaff-headed rig gains power as the wind draws aft.

RUNNING BEFORE THE WIND.

In a fresh breeze, this is the most dangerous point of sailing, because of the chance of an unintentional jibe. The danger increases if the boat yaws. From this follows the rule to keep the weights fairly well aft, though never at the extreme after end when running before the wind. Very careful steering is required; and, if the sea is heavy, the boom may jibe in spite of all the care that can be taken unless lashed to the lee rail or shroud by a "lazy guy."

Squalls are not as dangerous before the wind as when close-hauled or reaching, unless they are accompanied by a shift of wind. To reduce sail quickly in a gaff-headed boat, to meet this emergency, the peak of the mainsail may be dropped.

In running before the wind, the foresail is sometimes set on the side opposite the mainsail, a temporary boom being rigged by

using a boat hook or an oar. A boat sailing in this way is sailing "wing and wing."

If the sea is rough, it is well to avoid running with the wind dead aft. To make a course directly to leeward, the wind may be brought first on one quarter and then on the other, the mainsail being clewed up or the peak dropped each time the course is changed, if the breeze is strong enough to make jibing dangerous.

A serious danger in running before a heavy sea is that of "broaching to." The boat will yaw considerably, the rudder will be often out of water and the sails will be becalmed in the trough of the sea. The situation here is much like that of a boat running in a surf; and, as in that case, the yawing will be reduced by keeping the weights aft and by steering with an oar. The jib should always be set with the sheet flat aft. It helps to meet and pay her off if she flies to, against the helm. A drag towed over the stern is also helpful.

Another danger in running is that the boom may dip as she rolls and thus capsize the boat.

TACKING.

In tacking, the same principles apply to a boat as to a ship. An after sail tends to bring her head into the wind and a headsail to keep her off; but all sails, so long as they draw, give her headway and so add to the steering power of the rudder.

It is clear that a short full boat will turn to windward better than a long and narrow one and will require a much shorter distance for coming around. Thus a short boat is preferable to a long one for working up a narrow channel.

When about to tack, the coxswain should let her fall off a little to fill the sails and gain good headway, and he should watch for smooth water and avoid luffing into a breaking wave. The rudder should not be suddenly put hard over, but should be put over enough to have a good effect at first and then more and more as the boat swings; by the time the boat is swinging rapidly the rudder should be over about 30 or 35 degrees and held there.

Under ideal conditions, a boat close-hauled but with good way on, shoots into the wind as the tiller is eased down, making a good reach to windward and filling away on the new tack, with-

out a moment losing headway. The main boom is hauled amidships in a two-masted boat and nearly amidships in a single-masted boat, and, as the jib and the foresail lift, their sheets are let go. The boat comes head to wind and as she pays off on the new tack the sheets are hauled aft and she is steadied on her course. Under less favorable conditions, such as a heavy head sea or a very light breeze, tacking is not so simple.

If the boat gets in "irons," the jib sheet must be held out on the old lee bow to pay her head around. Care must be taken not to make a "back sail" of the mainsail. If she gathers sternboard, the rudder is shifted, and, if necessary, an oar is gotten out to help her around. The statement is sometimes made that it is lubberly to use an oar in a boat under sail. The lubberly part is the getting into a position where an oar is needed.

Carrying the weights forward is favorable for tacking, but when a boat has sternboard she may be helped around by putting a few of the crew on the (new) lee quarter, where, by increasing the immersion of the full lines of the counter, they may add to the resistance and cause the bow to fall off.

Attention may again be called to the fact that in squally weather a boat is in a dangerous position whenever she is without headway, because she can neither be luffed nor kept away in the event of being struck by a heavy gust. If, through ignorance or carelessness, the sheets are belayed at such a time, the danger is greatly increased.

On July 17, 1902, a sailboat full of people, in charge of an experienced fisherman, was capsized near the Isles of Shoals, off the coast of New Hampshire, under the following circumstances: The weather had been stormy, but had moderated. The wind was light but puffy, and there was a rather heavy sea running. The boat had tacked, but had not gathered headway and was lying in the trough of the sea when a squall struck her. The sheets were belayed. The helm was put down, but the boat, having no way, would not answer it. A sudden dash of spray caused the passengers to crowd hastily to leeward, and this, added to the effect of the squall and the sea, capsized the boat. Fourteen lives were lost.

In 1936, off Kent Island, Chesapeake Bay, four men were leisurely sailing in a small sloop. The night was dark but clear and a slight breeze was blowing. The sheets were belayed. A

sudden unnoticed squall struck the boat and capsized it. Three were drowned.

WEARING.

In beating to windward, boats ordinarily go about by tacking, because in tacking they turn into the wind and gain ground to windward. In wearing around they turn away from the wind losing more or less distance to leeward according to circumstances; still it is often possible to wear in winds so strong or water so rough that tacking ship's boats is impossible. It is often necessary to resort to wearing when maneuvering in close quarters such as clearing a dock or avoiding a collision.

In wearing, the helm is put up and the mainsheet eased off in order to help in bearing away and to get the maximum effect of the mainsail in increasing headway. When the wind comes nearly aft the sheets are rounded in smartly in such a manner that both the sail and the stern pass through the wind at the same time. As the sails jibe over, the sheets are eased off slowly and gradually. Care should be taken at this point, especially with a sloop rig, that the boat be not allowed to come up on the new tack too quickly as this may bring about a dangerous heel to leeward.

The details of the maneuver may vary considerably according to the conditions of wind and sea and peculiarities of the boat as to rig and trim. In boats of more than one mast, it is best to sail dead before the wind, trim in the sails, jibe them, and ease them out on the new tack in the order of jib, foresail and mainsail.

In a fresh breeze, as jibing is dangerous, the mainsail should be doused, brailed up or the peak dropped before the wind comes aft, and set again in time to bring her to the wind on the new tack.

REMARKS ON JIBING.

A sail is "jibed" when it is allowed to swing from one side to the other, the wind being aft or nearly so, and the sail full first on one side and then on the other. This may be done intentionally, as in wearing or in simply changing course, or it may come unexpectedly from a shift of wind or from the yawing of the boat. As it necessarily involves a violent swing of the sail, it puts a heavy strain upon the spars and rigging; it endangers

everyone in its path and causes the boat to lurch more or less deeply to leeward. At this point the boat shows a strong tendency to luff on the new tack, and if not met with the rudder the boat may be knocked down and capsized.

It is important in jibing that the sails be trimmed flat before the stern of the boat is brought into the wind, and after the boom has jibed over, the sheets should be started slowly and gradually. The trimming of the sheets should be so timed with the swinging boat that the helmsman does not have to check his swing and wait for the sails to be trimmed in nor should the boat be allowed to run with the sheets flat aft. In either case the boat loses speed and loss of speed is loss of control.

REEFING.

When an open boat begins to ship spray and water over the lee rail it is time to reef. A boat that is decked over may run with her lee rail awash; but when an open boat heels her gunwale close to the surface of the water it must be remembered that a fresher puff may bear the gunwale lower without warning, and that the moment it dips, the boat will almost certainly fill and capsize.

The details of reefing will depend upon the rig, but a few general rules may be laid down. The men should be stationed before beginning, and should all be required to remain seated. The boat is then luffed, but not to the point where steerageway and control is lost. One hand lowers the halliards of each sail as much as necessary, another hauls down on the luff and shifts the tack. The sheet is hauled in a little to let the men get hold of and gather the foot. The clew earing, followed by the points, are then passed, and the halliards manned. The sail is then hoisted and the sheets trimmed as the boat fills away on her course.

If the boat has more than one sail, it is a good plan to reef them one at a time.

VII.

Pulling Boats.

General. There is almost as much skill required in the handling of a boat under oars as in handling it under sail, but comparatively little of this can be taught by precept.

In going into a crowded or difficult landing, the crew pulls easily and keeps the boat under control with the oars as long as possible.

In going through a narrow entrance, good way is gotten on the boat before trailing or tossing oars.

A loaded boat holds her way much longer than a light boat.

In pulling across a current it is best to get a good range of two objects in line and steer by these to avoid being set down by the current.

Having a long pull against the tide it is well to run inshore where the tide is slacker than in midstream.

If taken in tow by a vessel it is best to take the towing vessel's line. This must be kept clear for letting go in an emergency. If towing astern a short towline should be used and if towing alongside a sea painter should be used for towing and the steering carefully watched.

In a seaway, one should board a vessel to leeward, taking care that the drifting vessel does not roll down on the boat. (See Chapter on "Rescuing the Crew of a Wreck.")

In picking up a man in the water, the approach should be made from leeward, bringing him on the weather bow, as otherwise in a seaway the pitching boat may drift down on the man and injure him.

In coming alongside in a seaway or a strong tide, the bow oarsman should be warned to look out for the boat line which will be thrown from the ship.

No attempt should be made to land alongside or to hook on under the davits while the ship has sternboard. The wash of the propellers may throw the boat out of control and endanger it.

There should always be a lantern filled and trimmed in the boat, and boats should never leave the ship for a trip of any great length without a compass. The weather is liable to thicken and for this reason the coxswain should at all times know the compass course to his destination and the force and direction of the wind and current.

Running a Line.

There are three general conditions to be met in this situation: against, broadside to, and with the conditions of wind and current.

In laying out against the adverse conditions, the greater part of the line should be coiled in the stern sheets, but enough end taken in the bow to make fast when the landing is reached. The boat then should pull away and the ship pay out line until sure of having enough in the boat to reach. The boat then pays out line and takes the end to the dock or bollard. There should always be plenty of good seizing stuff in the boat for making all secure, and if orders are to stand by the line, a hatchet should be ready for cutting loose. If the current is strong it will save time to take all the line in the boat, pull up and make fast, then bring the end back to the ship.

In laying out a long line broadside to the current, it will usually be necessary to have several boats, one to run away with the end, the others to under-run at intervals, floating the line and pulling upstream with the bight.

In laying out with the current, less line should be taken in the boat than otherwise. The boat is then pulled downstream and the line made fast.

The running of lines is normally done with power boats.

CHAPTER VIII.

HANDLING BOATS IN A SURF.

I. PRELIMINARY.

The handling of boats in a surf is an art in itself, calling for special knowledge and skill such as can be acquired only by practical experience. When undertaken by those who have not this experience, the danger involved can hardly be over-estimated.

Assuming that all measures have been taken which, under the existing circumstances, seem to offer the best chances for success, the actual running of the surf is performed by following two general principles:

First, the boat must be kept end on to the surf to avoid broaching; second, the boat must be able to meet and resist the force of the onrushing, breaking waves which otherwise will pick the boat up bodily and drive it along toward the beach out of control.

Methods of running the surf vary according to the circumstances of surf, type of beach and obstructions, set of the current along the shore line, weather, type and trim of the boat and the experience of the crew. The means and methods to be used must be decided after a consideration of these factors, which by their nature preclude the statement of other than general principles.

The following discussion is a guide to a successful landing:

II. HANDLING OPEN PULLING BOATS IN A SURF.

Of the various methods of landing a pulling boat on a flat beach which are described in the Rules of the National Lifeboat Association quoted below, the safest is probably that of backing in, keeping the bow toward the surf, pulling out to meet each breaker, then backing in as fast and as far as possible on its back.

A surf never looks as dangerous when seen from seaward as it really is; and a boat having to land through it should, if there

is a possibility of help from the shore, await such help before attempting to go in. As, however, it is often necessary to attempt a landing where no expert assistance is available, the following rules have been drawn up and published by the Royal National Lifeboat Institution of Great Britain:

RULES PUBLISHED BY THE ROYAL NATIONAL LIFEBOAT INSTITUTION, ON THE MANAGEMENT OF OPEN ROWING BOATS IN A SURF; BEACHING THEM, ETC.

In Rowing to Seaward.

As a general rule, speed must be given to a boat rowing against a heavy surf.

Indeed, under some circumstances, her safety will depend on the utmost possible speed being attained on meeting a sea.

For, if the sea be really heavy, and the wind blowing a hard onshore gale, it can only be by the utmost exertions of the crew that any headway can be made. The great danger then is, that an approaching heavy sea may carry the boat away on its front, and turn it broadside on, or up-end it, either effect being immediately fatal. A boat's only chance in such a case is to obtain such way as shall enable her to pass end-on through the crest of the sea, and leave it as soon as possible behind her. Of course, if there be a rather heavy surf, but no wind, or the wind offshore and opposed to the surf, as is often the case, a boat might be propelled so rapidly through it that her bow would fall more suddenly and heavily after topping the sea than if her way had been checked; and it may therefore only be when the sea is of such magnitude, and the boat of such a character, that there may be chance of the former carrying her back before it, that full speed should be given to her.

It may also happen that, by careful management under such circumstances, a boat may be made to avoid the sea, so that each wave may break ahead of her, which may be the only chance of safety in a small boat; but if the shore be flat, and the broken water extend to a great distance from it, this will often be impossible.

The following general rules for rowing to seaward may therefore be relied on:

1. If sufficient command can be kept over a boat by the skill of those on board her, avoid or "dodge" the sea if possible, so as not to meet it at the moment of its breaking or curling over.

2. Against a head gale and heavy surf, get all possible speed on a boat on the approach of every sea which cannot be avoided.

If more speed can be given to a boat than is sufficient to prevent her being carried back by a surf, her way may be checked on its approach, which will give her an easier passage over it.

On Running Before a Broken Sea, or Surf, to the Shore.

The one great danger, when running before a broken sea, is that of broaching-to. To that peculiar effect of the sea, so frequently destructive of human life, the utmost attention must be directed.

The cause of a boat's broaching-to, when running before a broken sea or surf, is that her own motion being in the same direction as that of the sea, whether it be given by the force of oars or sails, or by the force of the sea itself, she opposes no resistance to it, but is carried before it. Thus, if a boat be running with her bow to the shore, and her stern to the sea, the effect of a surf or roller, on its overtaking her, is to throw up the stern, and as a consequence to depress the bow; if she then has sufficient inertia (which will be proportional to weight) to allow the sea to pass her, she will in succession pass through the descending, the horizontal and the ascending positions, as the crest of the wave passes successively her stern, her midships, and her bow in the reverse order in which the same positions occur to a boat propelled to seaward against a surf. This may be defined as the safe mode of running before a broken sea.

But if a boat, on being overtaken by a heavy surf, has not sufficient inertia to allow it to pass her, the first of the three positions above enumerated alone occurs—her stern is raised high in the air and the wave carries the boat before it on its front or unsafe side, sometimes with frightful velocity, the bow all the time being deeply immersed in the hollow of the sea, where the water, being stationary or comparatively so, offers a resistance, whilst the crest of the sea, having the actual motion which causes it to break, forces onward the stern, or rear end of the boat.

A boat will, in this position, sometimes aided by careful oar-

steerage, run a considerable distance until the wave has broken and expended itself. But it will often happen, that if the bow be low, it will be driven under water, when the buoyancy being lost forward, whilst the sea presses on the stern, the boat will be thrown (as it is termed) end-over-end; or if the bow be high, or it be protected, as in most lifeboats, by a bow air-chamber, so that it does not become submerged, that the resistance forward, acting on one bow, will slightly turn the boat's head, and the force of the surf being transferred to the opposite quarter, she will in a moment be turned round broadside by the sea and be thrown by it on her beam-ends, or altogether capsized. It is in this manner that most boats are upset in a surf, especially on flat coasts, and in this way many lives are annually lost amongst merchant seamen when attempting to land, after being compelled to desert their vessels.

Hence it follows that the management of a boat, when landing through a heavy surf, must, as far as possible, be similar to that used when proceeding to seaward against one, at least so far as to stop her progress shoreward at the moment of being overtaken by a heavy sea, and thus enabling it to pass her. There are different ways of effecting this object:

1. By turning a boat's head to the sea before entering the broken water, and then backing in stern foremost, pulling a few strokes ahead to meet each heavy sea, and then again backing astern. If a sea be really heavy, and a boat small, this plan will be generally the safest, as a boat can be kept more under command when the full force of the oars can be used against a heavy surf than by backing them only.

* "This is by far the best method for anyone who has had little or no experience."

2. If rowing to shore with the stern to seaward, by backing all the oars on the approach of a heavy sea, and rowing ahead again as soon as it has passed to the bow of the boat, thus rowing in on the back of the wave; or, as is practised in some lifeboats, placing the after-oarsmen with their faces forward, and making them row back at each sea on its approach.

* "If this method is followed, have more men facing forward than aft, for if your boat starts to run, you will need lots of power to stop and hold her, and if she is not held, she will

broach-to and capsize. It is only the experienced surfmen who can run a boat for any distance and keep her from broaching-to on him, and they always come in on the back of a sea, but the trick is to know what sea to take and just where, and then all hands face aft and pull for all they are worth."

3. If rowed in bow foremost, by towing astern a pig of ballast or large stone, or a large basket, or canvas bag termed a "drogue" or drag, made for the purpose, the object of each being to hold the boat's stern back, and to prevent her being turned broadside to the sea or broaching-to.

Drogues are in common use by the boatmen on the Norfolk coast; they are conical-shaped bags of about the same form and proportionate length and breadth as a candle extinguisher, about two feet wide at the mouth and four and a half feet long. They are towed with the mouth foremost by a stout rope, a small line, termed a tripping line, being fast to the apex or pointed end. When towed with the mouth foremost, they fill with water, and offer a considerable resistance, thereby holding back the stern; by letting go the stouter rope and retaining the smaller line, their position is reversed, when they collapse, and can be readily hauled into the boat.

Drogues are chiefly used in sailing-boats, when they both serve to check a boat's way and to keep her end on to the sea. They are, however, a great source of safety in rowing boats, and the rowing life boats of the National Lifeboat Institution are now all provided with them.

A boat's sail bent to a yard, and towed astern loosed, the yard being attached to a line capable of being veered, hauled or let go, will act in some measure as a drogue, and will tend much to break the force of the sea immediately astern of the boat.

Heavy weights should be kept out of the extreme ends of a boat; but when rowing before a heavy sea the best trim is deepest by the stern, which prevents the stern being readily thrown on one side by the sea.

* "This method is good. A 'drogue' properly rigged and handled is excellent. (All boats except the 36-ft. motor lifeboats in the U. S. Coast Guard have drogues in their equipment and severe disciplinary action is taken against men in charge of stations if the drogues are not in the boats at all times.) Substitutes mentioned could be used but have the disadvantage that

when a smooth time comes, full advantage cannot be taken of it unless the improvised drogue is cast adrift.

"In the U. S. Coast Guard, while landing in a heavy surf, the two after oars are utilized to assist the man at the steering oar to keep the boat straight.

"An officer in the U. S. Coast Guard, who has much experience in landing through the surf, gives the following method as the safest and the best in landing through the surf with a crew inexperienced in surf work—place a forty or sixty-pound anchor in the bow with a hundred to a hundred and fifty fathoms of line, 2½-inch; just before getting into surf turn the boat to seaward, drop the anchor, pay out on the line, and one will usually find that the surge of the sea will take her to the beach fast enough; if not, use the oars to back in. Be careful to keep a strain on the line so that the boat will always be kept head-on to the seas. The boat can be eased on beach, the men jump out and haul her up, keeping the line fast, and when ready to launch the boat have her pointed right so she can be hauled out through the surf. This method is used a lot in Alaska, where landings are often made in strange localities. In that country there is little chance of having people around to help land or launch boats."

A boat should be steered by an oar over the stern, or on one quarter, when running before a sea, as the rudder will then at times be of no use. If the rudder be shipped, it should be kept amidships on a sea breaking over the stern.

The following general rules may therefore be depended on when running before, or attempting to land, through a heavy surf or broken water:

1. As far as possible avoid each sea by placing the boat where the sea will break ahead or astern of her.

2. If the sea be very heavy, or if the boat be very small, and especially if she have a square stern, bring her bow round to seaward and back her in, rowing ahead against each heavy surf that cannot be avoided sufficiently to allow it to pass the boat.

3. If it be considered safe to proceed to the shore bow foremost, back the oars against each sea on its approach, so as to stop the boat's way through the water as far as possible, and if there is a drogue, or any other instrument in the boat that may be used as one, tow it astern to aid in keeping the boat end-on to the sea, which is the chief object in view.

4. Bring the principal weights in the boat towards the end that is to seaward, but not to the extreme end.

5. If a boat, worked by both sails and oars, be running under sail for the land through a heavy sea, her crew should, under all circumstances, unless the beach be quite steep, take down her masts and sails before entering the broken water, and take her to land under oars alone, as above described.

If she has sails only, her sails should be much reduced, a half-lowered foresail or other small head-sail being sufficient.

Beaching or Landing through a Surf.

The running before a surf or broken sea, and the beaching or landing of a boat, are two distinct operations; the management of boats, as above recommended, has exclusive reference to running before a surf where the shore is so flat that the broken water extends to some distance from the beach. Thus on a very steep beach, the first heavy fall of broken water will be on the beach itself, whilst on some very flat shores there will be broken water as far as the eye can reach, sometimes extending to even four or five miles from the land. The outermost line of broken water, on a flat shore, where the waves break in three or four fathoms of water, is the heaviest, and therefore the most dangerous, and when it has been passed through in safety, the danger lessens as the water shoals, until, on nearing the land, its force is spent and its power harmless. As the character of the sea is quite different on steep and flat shores, so is the customary management of boats on landing different in the two situations. On the flat shore, whether a boat be run or backed in, she is kept straight before or end to the sea until she is fairly aground, when each surf takes her further in as it overtakes her, aided by the crew, who will then generally jump out to lighten her, and drag her in by her sides. As above stated, sail will, in this case, have been previously taken in if set, and the boat will have been rowed or backed in by oars alone.

On the other hand, on the *steep* beach, it is the general practice, in a boat of any size, to retain speed right on to the beach, and in the act of landing, whether under oars or sail, to turn the boat's bow half round towards the direction from which the surf is running, so that she may be thrown on her broadside up the

beach, when abundance of help is usually at hand to haul her as quickly as possible out of the reach of the sea. In such situations, we believe, it is nowhere the practice to back a boat in stern foremost under oars, but to row in under full speed as above described.

*"Since gasoline has supplanted oars and sails to a large extent, and motor boats are used extensively, I have noted with much interest the landing of pound boats on the New Jersey beaches (fairly steep beaches). These boats, thirty to forty feet long, carrying twenty or more barrels of fish, prefer a fairly heavy surf to land in. They watch their chance—come in on the back of a sea head on and the surf and momentum of the boat carry it well up on the beach.

"After forty years experience from Quoddy Head to Biloxi, and from Monterey, California, to Nome, Alaska, and much experience as an inspector of Coast Guard stations, and long talks with surfmen and fishermen, I have yet to see or hear of a boat landed on any kind of a beach in United States waters by turning the boat's bow half around to land; neither have I heard of this method being approved by surfmen in the U. S. Coast Guard nor by surf-fishermen.

"The reasons advanced against this practice are:

"(a) One must be perfectly familiar with the beach on which he is landing or he will turn too quickly and have his boat capsized with the probable loss of some of the men and the boat.

"(b) Not being able to hold his boat when he once starts to turn her will, in a heavy sea, stave in her bilge or planking."

III. NOTES ON THE MANAGEMENT OF BOATS IN A SURF.

By Lieutenant A. A. Ackerman, United States Navy.

From the ship a mile or two off shore, the surf may seem uniform, with no sign of a choice for making a landing. Looking at the backs of the breakers, as to leeward over the waves at sea, gives an inadequate idea of their height and abruptness. In fact,

*Comments by Captain Randolph Ridgely, Jr., U. S. Coast Guard, on Rules of the National Lifeboat Institution on the management of open rowing boats in a surf.

what appears to be a mere swash on the beach may involve much danger to a carelessly handled or deeply laden boat. Careful study will often give hints of important differences in the nature of the coast.

There may be stretches of sand beach backed by trees, the lights and shadows of which, according to their relative distances, indicate low-lying points, shallow bays, sand-choked river mouths, or even the lateral entrance of a lagoon into which the ship herself may safely pass. There may be bluffs, below which doubtless lie rocks, sometimes only shown in the churned-up surf when dangerously near. There is often a current along the shore, and this should be studied before attempting to land. Sometimes its direction changes with the tide; again it is perhaps part of an ocean current flowing constantly in one direction. Where there are cliffs, their débris is often swept into the form of an irregular breakwater towards the lee side. This shoal, being of varying height and lacking continuity, may be of little help when covered by high water, but at low water it sometimes affords all the lee required to make an easy landing.

Narrow cañons in long stretches of bluffs, or pockets in a rocky coast, sometimes mark quiet spots; the swell flowing in through deep water and breaking directly on the beach. Such places should as a rule be avoided until carefully studied. It may be possible to make use of them to land behind detached rocks or pass behind the breakers of the adjacent bluffs, but there are always sunken rocks to be feared; and the fall of the tide, or the setting in of a heavier swell, may suddenly turn the smooth seas at the entrance into heavy breakers.

A single rock, hardly far enough off shore to be shown on the chart as separated from the beach, will frequently have a quiet place in its lee, although the approach to it may at times be dangerous.

It is more difficult to choose a landing on a long stretch of sand beach; but wherever a shoal appears, or the surf stretches far out, a comparatively light surf, and perhaps even a smooth way in, should be looked for on the lee side.

Confused surf off the mouth of a lagoon or river, or the slanting breakers which sometimes run along the beach, as a rule indicate strong currents. When these are understood, a handy boat may sometimes dodge the breakers and work into smooth

water with surprising ease. There is always danger, however, that the stranger may be swept down into heavy surf, or while heading up against the current or main breakers, have the boat filled by cross-seas.

Often a number of the heaviest swells follow each other in succession, after which there is a short and comparatively mild interval. Such a recurrence of quiet spells, as well as the point at which the swells become dangerous by commencing to break, and that at which they fall into harmless confusion, should be watched for and taken advantage of in landing.

The number of lines of breakers or width of surf does not always determine the difficulty of landing, as the outer lines will be much the heaviest; and if these can be avoided or passed without shipping too much water, the others will probably not be dangerous to a well-handled boat. Notice should always be taken before entering the surf, especially where it is wide, of the probable drift of the boat. It may be set by the current down among rocks or into heavy breakers.

The beach, too, may present obstacles to a safe landing, apart from the surf. At high water, it may break directly on a steep shingle beach which would be difficult to climb, even without being obliged to drag the boat clear of the breakers. If assistance could be had from on shore, such a beach might be charged on the back of a breaker and the boat hauled up clear before the next one filled it. Working with the crew alone, however, the depth of water and poor foothold would usually prevent any but the most active crew in a light boat from landing without being swamped. At the same point, an easy landing might be made on the sloping sand beach below the shingle by waiting an hour or two for lower water.

Before entering the surf at a strange locality, it is well to lie off it for a while, noting its peculiarities and accustoming the crew to them. Dangerous breakers may form and pass, but the quieter intervals are very encouraging.

Speaking generally, a very light and buoyant boat, with a crew of as small a number as possible to handle it, will pass in and out through moderate surf with ease, while a heavy ship's boat with a powerful crew would at least take on board considerable water. Beyond a certain point, the added strength of a man does not begin to compensate for the increased weight. The require-

ments of a good surf boat differ materially from those of a deep-sea life boat, yet they are alike in some particulars. The difference lies mainly in the fact that the latter is designed to ride in a rough sea, which, since the boat rises and falls with it, does not have the battering force of a breaker. The surf boat, on the other hand, perhaps while lying dead in the water, or carried out by oars and undertow, must meet and pierce or surmount a wall of water advancing with great velocity.

A very light and broad-beamed, single-banked, six-oared whale boat is perhaps the type of ship's boat in which the best proportion of power to resistance and weight moved is likely to be obtained.

If time permits, a towing-post should be fitted in the bow for veering a surf-line and this may be suddenly required to take great strain when the boat is struck by a breaker.

Besides possessing the buoyancy due to lightness of material, it would be a great advantage for the boat to be fitted with light air-tanks filling all unoccupied space and so reducing to a minimum the capacity for shipping and holding water. In fact, an extreme type of surf boat would somewhat resemble the Esquimo's kayak, in which the boat has a cover, the only opening of which is gathered tightly around the occupant's waist.

Great *sheer* is important, and the upper strakes should flare somewhat at bow and stern to prevent their dipping under when the opposite end of the boat is lifted high on the side of a breaker. The flare of upper strakes, however, should not amount to such bluffness as will increase resistance to cutting through the crest of a wave. To permit the boat to rise and fall quickly in response to the swell, weights should be kept out of the extreme ends.

The underwater body of the boat should offer as little lateral resistance as possible to the water. Should she, in pulling out to meet a breaker, be inclined slightly from the normal and be carried back, however little, her keel, rudder-post and run would be resisted and retarded by the dead water on the front of the breaker, while the bow would be swept rapidly around turning the boat more and more broadside on, until the gunwale dips and it finally rolls over. The coxswain must in such a case attempt to pry the stern around with his steering-oar and the crew make every effort to get way on the boat and surmount the breaker before the turning action has culminated in a capsize. If the

bottom of the boat is rounded and smoothed off in every direction, the water has very little hold either for turning it against the leverage of the steering-oar, or to roll the boat over should it broach-to. In fact, a light dory has been known to be swept broadside on for a long distance before a breaker without capsizing. The smooth bottom offered so little resistance to the dead water on the shore side of the breaker that there was very little tendency to trip the boat up.

High freeboard, high roomy thwarts and favorable positions for oarsmen and coxswain to exert their strength, are all important qualities. The modern navy whaleboat is a great improvement over the old one in these respects. It is, however, necessarily a compromise; and with very little alteration it could be greatly improved for passing the surf. Its propelling power should be nearly equally spaced about the center of buoyancy, which may be accomplished by placing an additional thwart in the stern sheets and leaving the forward thwart vacant. Passengers should sit on the bottom of the boat between thwarts; all unnecessary weights and gear should be removed. The coxswain should have a grating lashed over the stern sheet benches to give him a good foothold. Swivel rowlocks should be used; there is great danger of fouling the oars in the surf and it would then be very difficult to free one from an inserted rowlock before it had caused the boat to broach-to. Stretchers and boat-breakers should be lashed down and all other unnecessary gear dispensed with.

The subject of oars merits consideration. The steering-oar should be broad, stiff and not too long. Its exact length depends upon the boat and the height of the coxswain's platform; eighteen feet may be regarded ordinarily as a good length. A longer oar may be used to advantage at sea and its need may be felt at times in the surf; for example, when the stern is raised on the crest of a breaker and the blade of the oar barely reaches the water in the trough. On the other hand, when the boat is in a dangerous position and being carried back, a long oar is worse than useless, as it is almost impossible to keep its blade from catching in the dead water, where it tends to turn her broadside on. The other oars should also be light and stiff to permit easy handling and quick application of power. On troubled water, either at sea or in the surf, oars which exceed a certain

length dependent upon the beam and freeboard of the boat are a nuisance. They cannot be handled quickly, wear the men out and are certain to strike on the back stroke or foul each other. If, in addition, they are springy, by the time the power is well applied in one direction, the boat may be turned or tilted and most of the stroke lost. No hard and fast rule can be given for the length of oars; that had better be determined by actual test in each particular boat. It will seldom, if ever, however, be found advisable to employ in a single banked boat, an oar longer than twice the beam at the thwart plus the freeboard at the oarlock.

Whichever way of landing is adopted, a conical drag, towed ten to twenty fathoms astern, will be of great assistance. It should have a tripping line to invert it when it is not required to check the boat. Too much reliance should not be placed upon the drag, however, for though it will always assist to keep the boat pointed fair to the breakers when the line is hauled in briskly by a couple of men, there is not the positive assurance of holding the boat that is given by a surf-line attached to a well-bedded anchor planted outside the surf.

NOTE.—A surf-line consists of a line, one end of which is secured to seaward outside the line of breakers, either to an anchor, as stated above, to an anchored boat, or to a larger heavier boat underway such as a motor launch. The other end is taken in the landing boat. The purpose of the surf-line is to provide a heavy strain or drag on the end of the landing boat, to seaward, in order to prevent the boat broaching to when met by a heavy oncoming wave. The men tending the surf-line veer or hold as necessary to cause the boat to meet each oncoming wave end on.

There are occasions when the use of such a surf-line and anchor is invaluable. Among them may be noted the landing in a large or unwieldy boat; landing with a weak or inexperienced crew, or in high surf where it is necessary to return, or in any case where it seems pretty certain that the crew will be unable to maintain control over the boat with their oars. On the other hand there are certain disadvantages connected with the use of the surf-line. There is a current along almost every beach and if the surf is wide, a boat going out may drift down so far that when the dangerous breakers are reached, the line to the anchor leads broad off the bow and tends to turn the boat rather than steady it head-on to the breakers. Should a boat using a surf-

line be capsized in the outer surf, the coils of line will probably knot and tangle so as to prevent the boat from drifting in.

Whenever the line is used, a hatchet should be kept close to the bowman's hand with which to cut the line should it become necessary. In going in where the surf is wide or there is a current, the line may be used to pass the outer breakers and then abandoned. If a bucket is tied to the end, it may be picked up again and used on going out. The anchor should be buoyed with spare oars or other gear so as to recover it should the boat be obliged to abandon the line or to cut it in coming out.

All unnecessary articles are taken out of the boat. The water-breaker is tightly plugged and lashed down, as are the stretchers and buckets for bailing. The men shift into light clothes without shoes. If the weather is sufficiently cold to require it, dry clothing may be carried in the air-tanks, which should, however, be carefully inspected and all unnecessary articles removed. A hatchet, copper tacks, sheet lead, and roll of felting should also be carried for use in case the boat is stove. If the beach is distant, it may be possible to go under sail, or to be towed by another boat so as to keep the men fresh. The presence of a second boat would also be of great assistance, if it was used to distribute oil over the water abreast the landing, for although the quieting effect of oil is much less marked upon a surf than upon deep sea waves, there is abundant evidence that its value is considerable, especially in the comparatively deep water where the outer and most dangerous breakers form.

A second boat lying outside would be an encouragement to a crew pulling out from shore, and might be of great assistance to the probably exhausted men after their trip through the breakers.

In going out, the time of start, though important, is less so than when coming in, as it may be possible to pull half-way out without taking water on board or meeting dangerous surf. If a surf-line is used, take the boat up the beach until it appears that when carried down by the current and hauled out at the same time it will reach the dangerous space with the line fair to the anchor. Station two active, powerful men to haul in the line, as more progress will be made in this way than if they took oars. The four after-oarsmen steady the boat, standing in the water opposite their thwarts, oars apeak. Put the passengers aboard, haul taut the line, and commence walking out the boat,

the coxswain at the stern. As soon as the boat leaves the bottom the men climb in and take their oars, pointing them to prevent drift until ready to start. The intention is to so time the arrival of the boat at the outer line that no heavy breakers will be met at that point. Varying width of surf and speed of boat may make this difficult of attainment.

At the start the men, pulling and hauling, force the boat rapidly through the water. Irregular waves splash into the boat; later they become too large to be pulled through without taking much water on board. It is then best to check headway, tauten the line, and peak oars as the breaker passes. So the boat works out, obviously passing many more breakers than when coming in. Gradually the filling boat becomes sluggish, difficult to pull and steer. In this condition it may be capsized if only slightly turned, and it may now be better to go back, bail out, and try again, than to struggle on and risk an almost certain capsize in the heavier breakers.

A properly pointed boat may succeed in passing through a breaker that it cannot hope to ride. The water may fill it to the thwarts, in which condition it will capsize at a touch, but once clear of the breakers it may be bailed out and enabled to meet the waves of any ordinary sea in safety.

IV. USES OF THE SURF-LINE.

Where no help may be expected from the beach but a ship's boat such as a motor launch is available, a surf-line may be made fast to the stern of the motor launch and the rest of the line taken in over the extreme end of the bow of the landing boat. The motor launch either anchors, or where a current sets along the beach, holds her position by using her engines. The landing boat backs in carefully, veering the surf-line over the bow as necessary, and, assisted by the oarsmen thus keeps the boat at all times bows on to the surf. The surf-line may be buoyed with life jackets at intervals to give the line the necessary flotation as otherwise the line may sink allowing it to form a large undesirable bight which may foul the bottom. The latter is to be especially guarded against where a rough or coral bottom exists.

The surf-line may be used in conjunction with a hauling line from the shore to the boat. This arrangement could be used

where the boat was to make several trips back and forth through the surf and where competent assistance could be expected from the beach.

This method has been used successfully by the United States Coast Guard (See Plate **93**).

The surf-line and hauling lines are secured to the extreme ends of the surf boat and led to the anchored boat to seaward and to the shore where they are tended by experienced men. The boat is simply hauled back and forth through the surf. Assistance from the men in the boat is unnecessary, the veering and hauling being all done by the men in the anchored boat or ashore as necessary to meet the waves and bring the boat through the surf. As many as fifteen trips a day were made in this case, several times with no men in the boat. A one knot current was setting along the shore line at the time but by the use of the two lines no difficulty was encountered in keeping the boat end on to the surf.

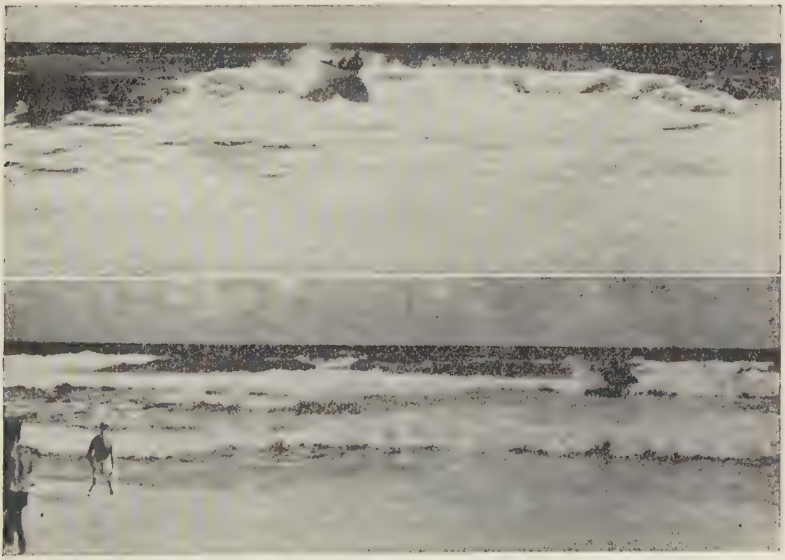
When surf is not a major problem but a simple landing with a large motor launch is to be made and where the current or wind may turn the boat broadside to the beach, anchored surf-lines may be effectively used.

As the boat heads in toward the beach, an anchor is dropped from the quarter well outside the rough water. The boat, under power, then quarters off toward the opposite side and another anchor is let go from the opposite quarter, preferably to windward, in such a position as to give the largest possible span. The boat is then headed for the beach, veering the surf-lines as necessary. The bow is rammed firmly into the sand on the beach. The boat is then held bows on to the beach with her nose in the sand, the surf-lines tending at an angle from each quarter and resisting the tendency of the boat to bring up broadside to the beach. Should the boat get broadside on she might sustain injury to her propeller or rudder and getting clear of the beach would be difficult.

With the boat held bows on to the beach with the surf-line, getting clear involves nothing more than heaving on the surf-lines and backing the engine. The surf-lines may be used to overcome any tendency of the boat to back into the wind and sea or to back to port. As in all cases where lines are over the side, care must be taken that the lines do not foul the propeller.

SURF LINE IN USE.

LANDING STORES THROUGH THE SURF, BAKER ISLAND—U. S. COAST GUARD. UPPER—BOAT COMING IN THROUGH SURF. LOWER—BOAT GOING OUT.



LANDING STORES THROUGH THE SURF, BAKER ISLAND—U. S. COAST GUARD. UPPER—GOING OUT. LOWER—COMING IN.

In any case where a power boat is landed on a sandy beach it must be remembered that the sand kicked up by the turbulence of the propeller stream or surf may enter the cooling system through the injection and possibly put the engine out of commission.

V. NOTES ON HANDLING BOATS IN A SURF. By Commander E. J. Sullivan, U. S. Coast Guard.

One, and the most advantageous, of the methods to land boats through the surf and on the beach is to watch the break (of the seas) very closely and lay the boat as close to the breaking seas as possible, taking care that she does not get in the curl or break. The great advantage in this lies in the fact that it allows sufficient time to make the run to the beach before another sea builds up, because the boat is in close to the beach when the run-in is started. When applying this rule it should be remembered that during rough seas there is a succession of seas following each other, at least three or four coming in a series, and if an experienced man is attempting to land under these conditions he will always lay as close to the break as possible and wait until the last sea of the series has passed and has broken just inshore of the boat. Then, as the sea breaks and flattens he will head for the beach behind it, using all speed possible but keeping his boat always under good control so as to stop her headway in a few seconds should another sea build up behind him before he has reached the beach. The rule applies primarily to those boatmen who have sufficient experience and knowledge of the surf that would enable them to determine just where the seas are breaking, the height of the sea, the time it takes it to break after the first curl is noted. In any case, when attempting to land through a rough surf, the person in command of the boat should be deliberate and cautious before making the final run for the beach, and when he does start the run conditions should be as good as his judgment can make them. When there is any doubt that the boat may run with the sea and broach to, the "quarter-oars" steering method should be used; one man standing on each quarter with an oar ready to assist the steersman.

In launching a boat off the beach with a well drilled crew the following method is used: as soon as the bow floats the two bow

oarsmen man their oars and hold the boat's head into the seas, the other men having shipped their oars in their oarlocks, standing alongside the boat holding to the gunwale ready to board on command. As the command is given ("In amidship" or "In all") the men leap into the boat and take their thwarts, getting down to the oars as soon as possible. The boat is then kept head to the sea and pulled smartly away from the sand break (which is the last sea to break on the beach) as soon as opportunity affords. Headway must be kept on the boat in going to sea or the seas will drive her back on the beach and probably up-end her. However, good judgment must be used to keep the boat from striking the seas as they break as the greatest danger of seas lies in the hollow break. If the boat is properly handled so as not to allow a sea to break directly into her she can be carried from the beach and over a very rough bar. By waiting a chance and watching the succession of seas as they pass, both landing on the beach and going to sea from it may be accomplished with a minimum of danger. The use of drogues is a well proven aid in coming in through a rough surf.

It is the writer's opinion that should an inexperienced person attempt to land a boat on the beach through a rough surf, he should strictly observe the fundamental rules, as follows:

Keep the boat's head at right angles to the seas and never let a sea come up on the quarter for the boat will surely broach to.

Keep the trim slightly aft.

Do not be too hasty to land; lay off and study the seas and surf until their behavior and condition is well understood. On most beaches there is usually some point where the seas or surf are not as high or rough as at other places, due to a break in the bar or a steep beach.

Always be prepared to hold the boat and if necessary back water if an approaching sea appears to be about to break behind the boat.

In landing with a boat under oars, a short, fast stroke is best. The use of a long stroke prevents absolute control of the head-motion in that it takes longer to come to "Hold Water" from a long stroke than from a short one. Then, too, the sea may leave the oars when in the process of a long stroke and the oarsman might catch a crab or fall backward into the boat when the pressure on the blade ceases.

CHAPTER IX.

GROUND TACKLE.

Classification.

In the U. S. Navy all ship's anchors and all chain or wire rope cables for use with these anchors are classed as ground tackle. In addition, all shackles, swivels, fore lock pins, split keys, dip rope, clear hawse pendants, chain stoppers, shackle tool kit, used for working with anchor cables or anchors are classed as ground tackle.

General.

There has been an awakening of interest in anchor design that holds promise of giving to seamen anchors of greater holding power per pound of weight and more assurance that the anchor will hold without dragging, combined with greater ease of stowing and handling. The three factors instrumental in the revival of interest in anchor design are:

1. The success of cast steel and die-locked chain which enabled lighter chain to be used.
2. The Washington and London treaties placed a premium on the weight of equipment used on naval vessels.
3. The large flying boats demand ground tackle as light and as efficient as naval architectural skill can produce.

Recent experiments indicate that in the not distant future anchors will be rated on a basis of holding power, so that captains of vessels will know that the anchor or anchors with which their ship is equipped will withstand so many pounds pull before it breaks out and this pull can be calculated with sufficient exactness for different kinds of bottom to be of practical use to the ship's officers.

It is of interest to note that the area of the flukes rather than the dead weight of the anchor is the determining factor of the holding power of an anchor. In this connection, it can be stated that in an emergency the holding power of an anchor can be

increased by riveting plates to the flukes so as to add more area there.

Recent experiments, both in England and in this country prove the superiority of the old fashioned or stocked anchor over the stockless anchors.

I. ANCHORS.

In general, there are two types of anchors used by ships—the old fashioned type (Plate **94**) and the patent or stockless anchors (Plates **95** and **96**).

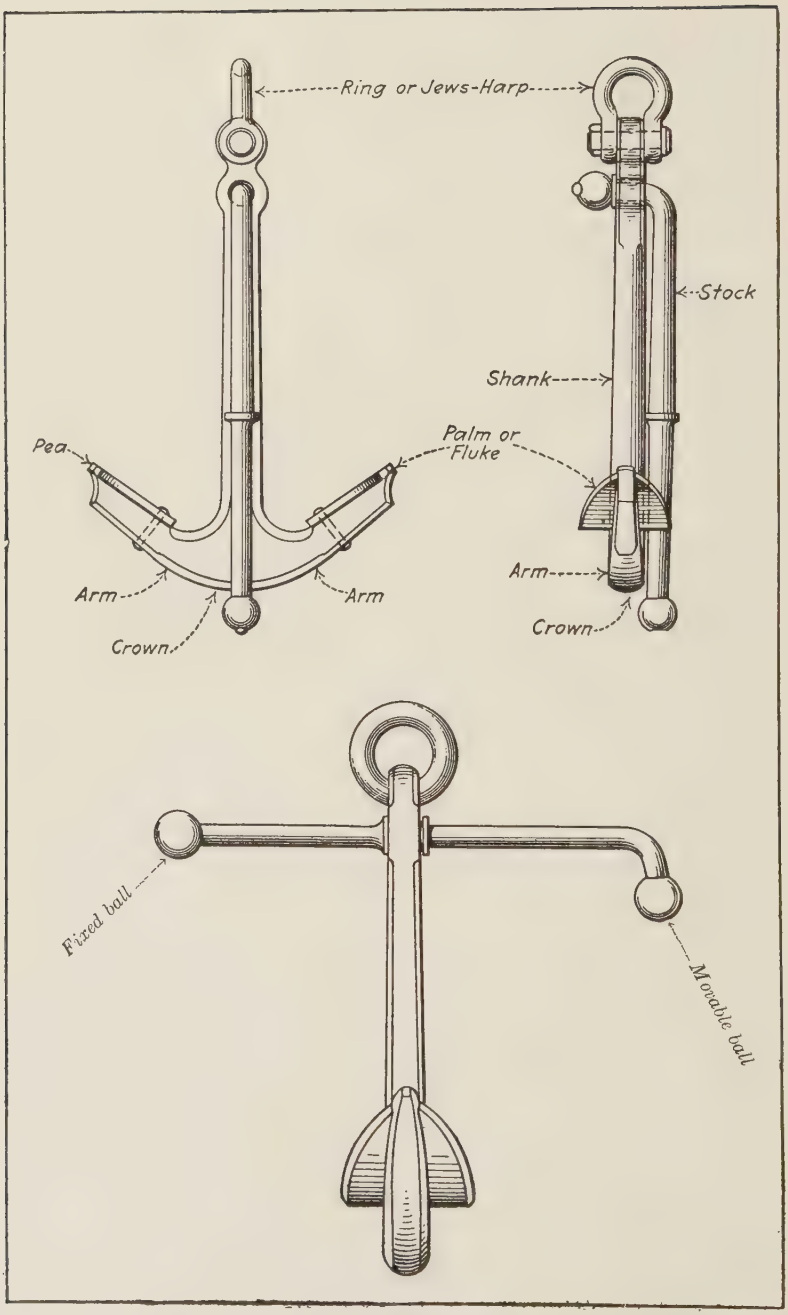
When an old-fashioned anchor is let go in water fairly deep, it strikes the bottom crown first, and immediately falls over until it rests on the end of the stock, the arms lying horizontally. From this position any drag of the chain to one side capsizes or "cants" it, pulling the stock down horizontally upon the bottom and pointing one of the flukes fair for biting. As the drag continues, the fluke is forced into the ground. If the anchor is well designed and the chain pulls approximately parallel to the bottom, the heavier the pull on the chain the deeper the fluke digs in. For this reason, it is imperative to use such a scope of chain as will ensure that the pull of the chain on the anchor is approximately parallel to the bottom.

When a stockless anchor is continuously dragged one fluke penetrates the bed. At a further stage, the anchor eventually rolls right over, the head tumbles the other way, and the cycle begins again. It was found that the period of this motion is slower in soft than in hard beds, but the motion occurs in soft mud as well as in sand and shingle mixture.*

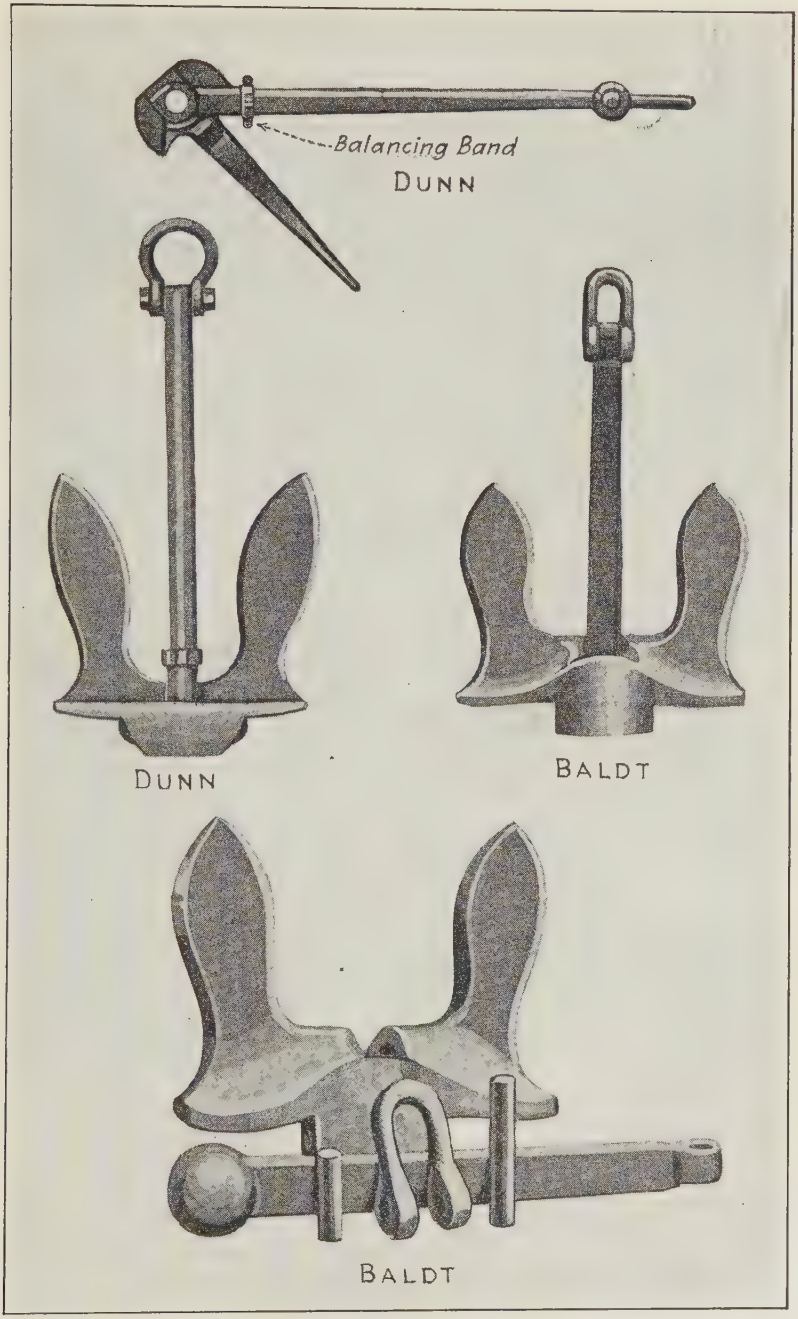
In view of the above, British experiments are being conducted to improve the stability of the stockless anchor.

The principal advantage of the patent anchor is the enormous gain in convenience of handling and stowing. It can be laid down as a rule that the patent anchors need a longer scope of cable to insure holding than would be needed on an old-fashioned anchor under the same conditions. This is because a slight upward pull on the jew's harp (or ring) tends to break out the patent anchor, whereas the same pull would tend to make the flukes of the old-fashioned anchor bite deeper.

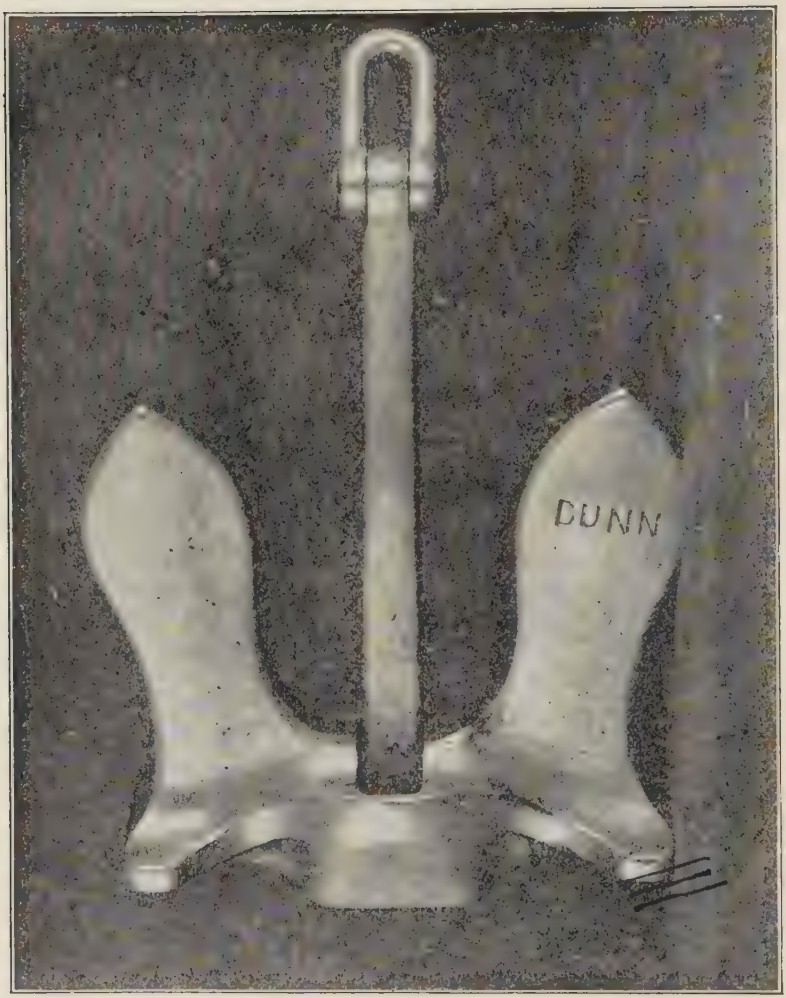
* From "Engineering," June 5, 1936, page 625, a paper by Wing Commander D. F. Lucking, R. A. F.



OLD FASHIONED ANCHOR. (See Plate 98 for "balancing-band" for hoisting and how anchor is secured on "bill-board.")



PATENT ANCHORS.



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THE DUNN ANCHOR.

Some features common to all stockless (patent) anchors are:

1st. The arms are pivoted upon the shank and can swing from thirty to forty-five degrees on either side.

2nd. The palms are in the plane of the arms instead of at right angles to it.

3rd. It results from this construction that both flukes should bite if either one does.

4th. To insure the flukes biting, the arms carry at the crown a shoulder with a sharp edge which takes on the bottom and throws the arms downward.

Plate **97** shows two methods of stowing anchors.

Anchors designed to be stowed on a bill board are fitted with a balancing band on the shank (Plate **95**, Dunn), and are handled by a purchase or a pendant from a heavy davit (Plate **97**). This davit turns about a vertical axis, plumbing the proper point of the bill board at one part of its train and swinging out well clear of the bow at another part. The davit is usually hinged so as to turn down flat upon the deck when not being used.

At the davit head is hooked either a heavy single block (Cat block) swivelled and carrying a pendant (Cat pendant), or the upper block of a purchase, usually three-fold. This pendant should be preferably of wire. Wire works smoothly and is better adapted, by reason of its elasticity, to stand the sudden jerks which are unavoidable in stowing anchors. The pendant carries a large hook of special design at its (outboard) end. The anchor is hove up to the hawse pipe where the balancing ring is caught with the hook on the pendant. A strain is taken on the pendant and the chain veered, the anchor swings to the pendant, the anchor davit is trained to plumb the bill board and the anchor landed where it is secured on the bill board by passing the ring stopper forward of the balancing ring and the shank painter at the crown end of the shank. Both the ring stopper and shank painter are then secured to the lugs shown on the releasing bar and the trigger locked as shown in Plate **98**.

The windlass brake bands are designed so that when kept in good condition and properly set up, they will hold the weight of the anchor, but it is important to realize that they cannot be depended on implicitly when life and limb are at stake. For ex-

ample, in catting for stowage on billboard, the cat pendant should be hooked in the balancing link and the hauling part of the cat fall taken with several turns, suitably taut, around the barrel of the windlass, before the wild cat is disconnected to take the weight of the anchor on the brake. In this manner the anchor will be prevented from taking charge in case the brake should not hold its full weight. Serious accidents have occurred on failure to take this precaution. Strict compliance with the above procedure is demanded.

In ships whose anchors house in their hawse pipes, the hawse pipes are specially designed for this purpose. In housing these anchors, the anchor chain is hove in until the anchor rests snugly in its hawse. The housing chain and riding chain stoppers are secured and set taut, the chain is walked back until these stoppers take the strain evenly, then the wildcat is disconnected and the brake set taut.

The larger men-of-war usually carry three bower anchors, one stream anchor weighing 5000 to 6000 pounds (this is sometimes carried astern), two or more kedge anchors and boat anchors as required.

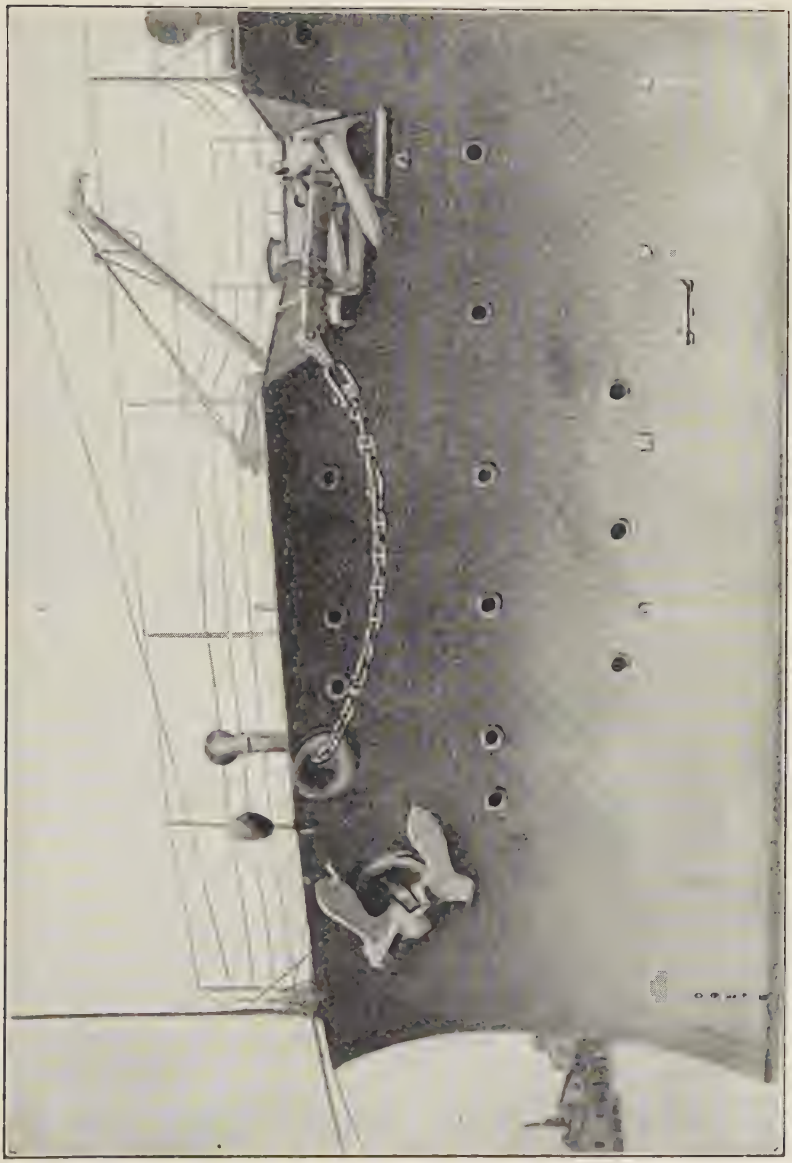
A Sheet Anchor was formerly an anchor heavier than the bowers, kept in reserve for an emergency. The term has now no significance.

Anchors in the latest capital ships are now designated as Stem Anchor, Starboard Bower and Port Bower.

A Stream Anchor, in days when men-of-war were frequently called upon to navigate rivers, was carried at the stern (originally) for use on occasions when it became necessary to drop an anchor astern to avoid swinging to the current or for any other reason. Later the term came to mean an anchor of medium weight, wherever stowed and for whatever purpose used. In this sense, the designation is conveniently retained.

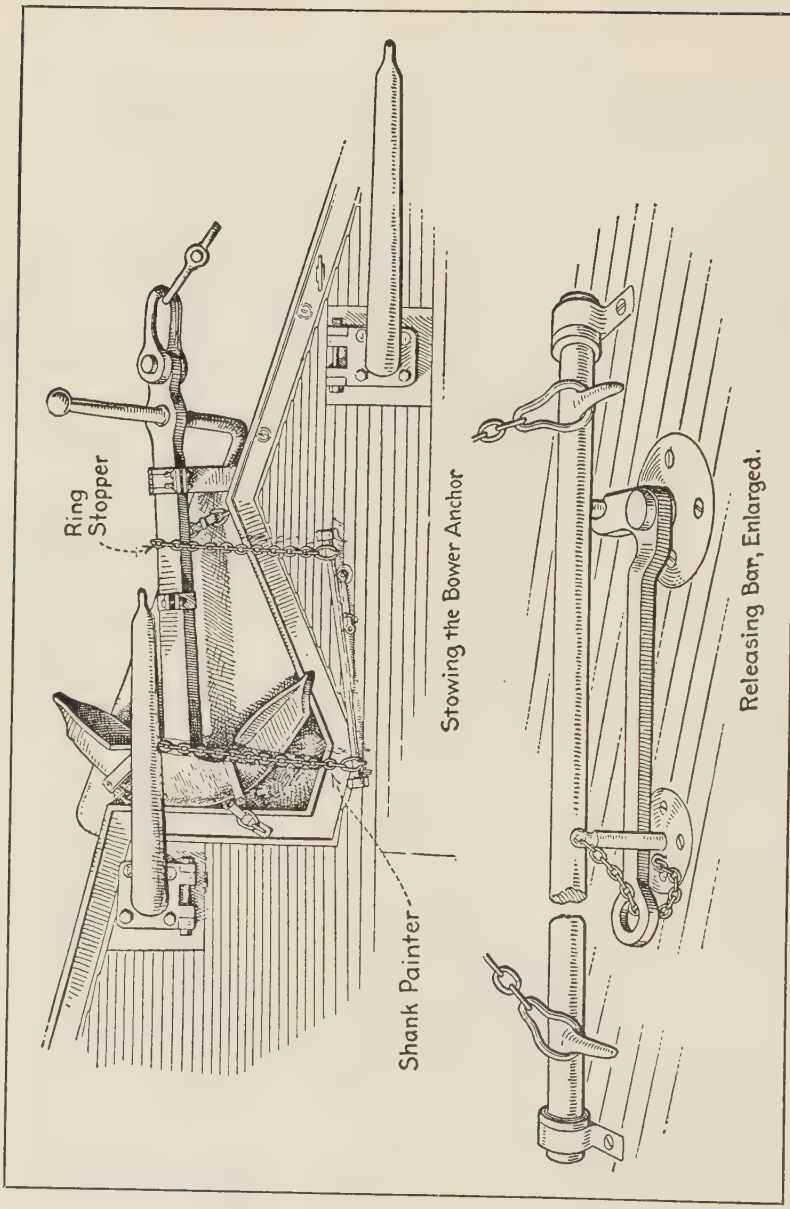
Any anchor carried at the stern is conveniently designated as a "Stern Anchor," without reference to its weight, or purpose.

Every anchor when purchased for Navy use has cast or cut in its crown a serial number, assigned by the Bureau of Ships, the initials of the inspector, the name of the manufacturer or commercial name of the anchor. On the opposite side of the crown the weight of the anchor in pounds, the year of fabrication and "U.S.Navy" is cast or cut.



BOW OF A BATTLESHIP, SHOWING ANCHOR STOWAGE.

Plate No. 98



DETAILS OF ANCHOR STOWAGE ON "BILL BOARD."

II. CHAIN CABLES AND APPENDAGES.

Prior to 1924 wrought iron chain was the standard type in all naval vessels for making up anchor cables. In 1924 cast steel chain was adopted as the standard to replace wrought iron chain in all sizes. Subsequent to the adoption of cast steel chain as standard for use on naval vessels there was developed a type of chain known as "Di-Lok."

Service tests of the "Di-Lok" chain were so satisfactory that this chain was adopted as the standard for naval ships.

One of the outstanding features of die lock chain is its uniformity of strength. While the cast steel chain is generally satisfactory in this respect, this type of chain may vary in strength due to different degrees of casting perfection. Properly manufactured die lock chain always breaks through its solid section in the female half of the link. Failure occurs in this section rather than the male section by virtue of the fact that the male section is heat treated, quenched and tempered before assembly, whereas the female section is in the "as forged" condition. This is necessary because the female section must be heated to a forging temperature for assembly and subsequent heat treatment of the assembled link might adversely affect the hardness of the reduced stems and collars of the male section.

Chain is designated as to size by its "wire diameter," which is the diameter of its common or "A" links. The length of a link of old wrought iron chain was 5.7 times the wire diameter of the link. This was known as the Navy link. In the interest of uniformity for purchasing advantages to the government, the Navy has adopted the "commercial link," which has a length of six times its wire diameter. When new type chain is issued to ships for replacement of chain that had the "Navy link," new wildcats will have to be installed to take the longer length of the "commercial link."

Chain cable varies in size from ¾-inch to 3½-inch wire diameter. A good approximation for all types of chain of its weight per fathom in pounds can be had by the formula:

$D^2 \times 60 =$ weight per fathom, where D is the wire diameter of the chain in inches.

Every shot of chain used in the Navy bears a serial number that is stamped, cut, or cast on the inner side of the end links of

each shot at the time of manufacture. In the case of cast steel chain, this number is preceded by the letters "C.S." If an end link is lost or removed from a shot, this identification number should be cut or stamped on the side of the new link of the altered shot. "U.S.N." in raised letters is on the obverse side and the wire diameter of the link on the reverse side on alternate links only on cast steel chain. Each shot of die-locked chain has a serial number and date of manufacture stamped on the inner side of the end links. Die-lock chain manufactured subsequent to April 1932, will have the studs of such chain marked with U.S.N. on the obverse side and the wire diameter of the chain on the reverse side. It is to be noted that the studs of cast steel and die-locked chain are integral parts of the link instead of being welded in as they are on wrought iron chain; but the studs of die-locked chain are split in the middle. This is due to the way the chain is manufactured (Note Section A A on Plate **99.**)

With the successful development of the Kenter shackle and detachable links (Plates **100**, **101**) all shots of chain are made in fifteen fathom lengths. Prior to this, the first shot aft of the bending shot was 40 fathoms in length to lessen the chance of the "U" connecting shackle being on the wildcat as the anchor broke ground.

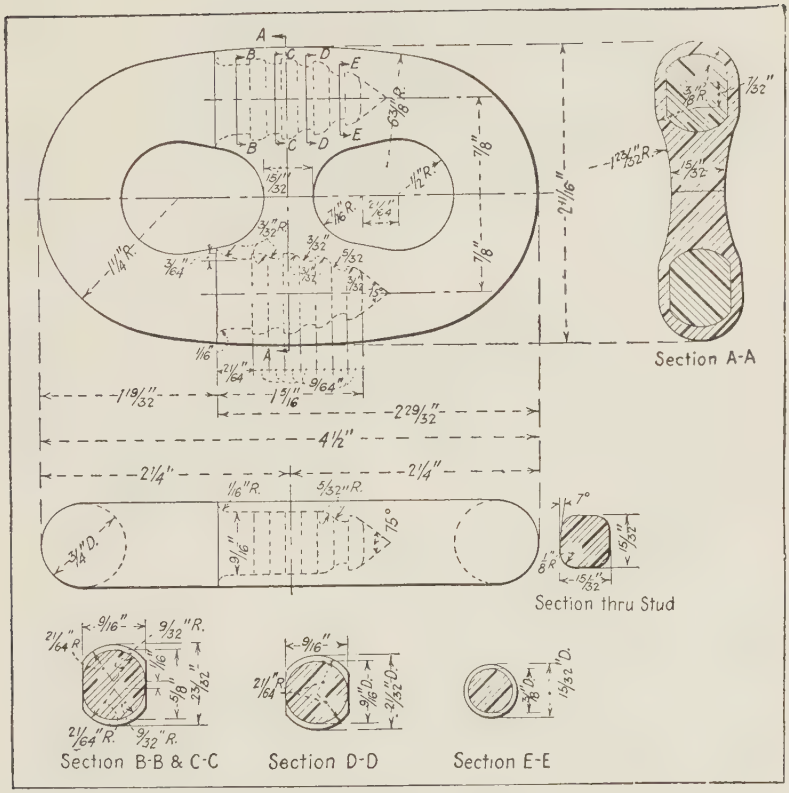
Chain Measurement.

L = length of chain, in inches.
N = number of links in length L.
D = wire diameter of chain in inches.
$2D\ (1 + 2N) = L$.
To find the number of links per fathom use:

$$\frac{6 \times 12}{4D} = \frac{72}{4D} = \frac{18}{D}.$$

Assembly of Chain.

Chain is assembled by bending the outboard swivel shot (Plates **102** and **103**) to the jew's harp with the bending shackle. This is put on with crown aft (Fig. 3, Plate **104**). Then connecting the several shots of chain, one to the other by connecting shackles (usually Kenter connecting shackles or detachable links.)



$\frac{3}{4}$" DIE LOCKED CHAIN.

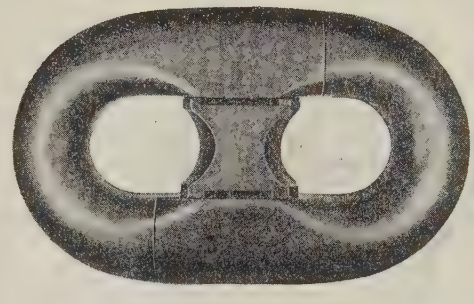


FIG. 1. ASSEMBLED

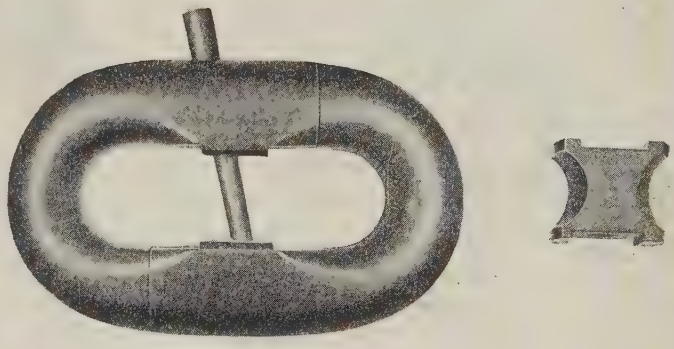


FIG. 2. PARTIALLY ASSEMBLED

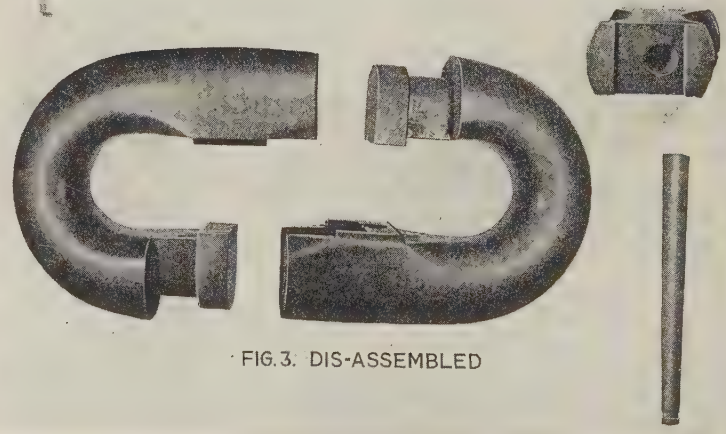
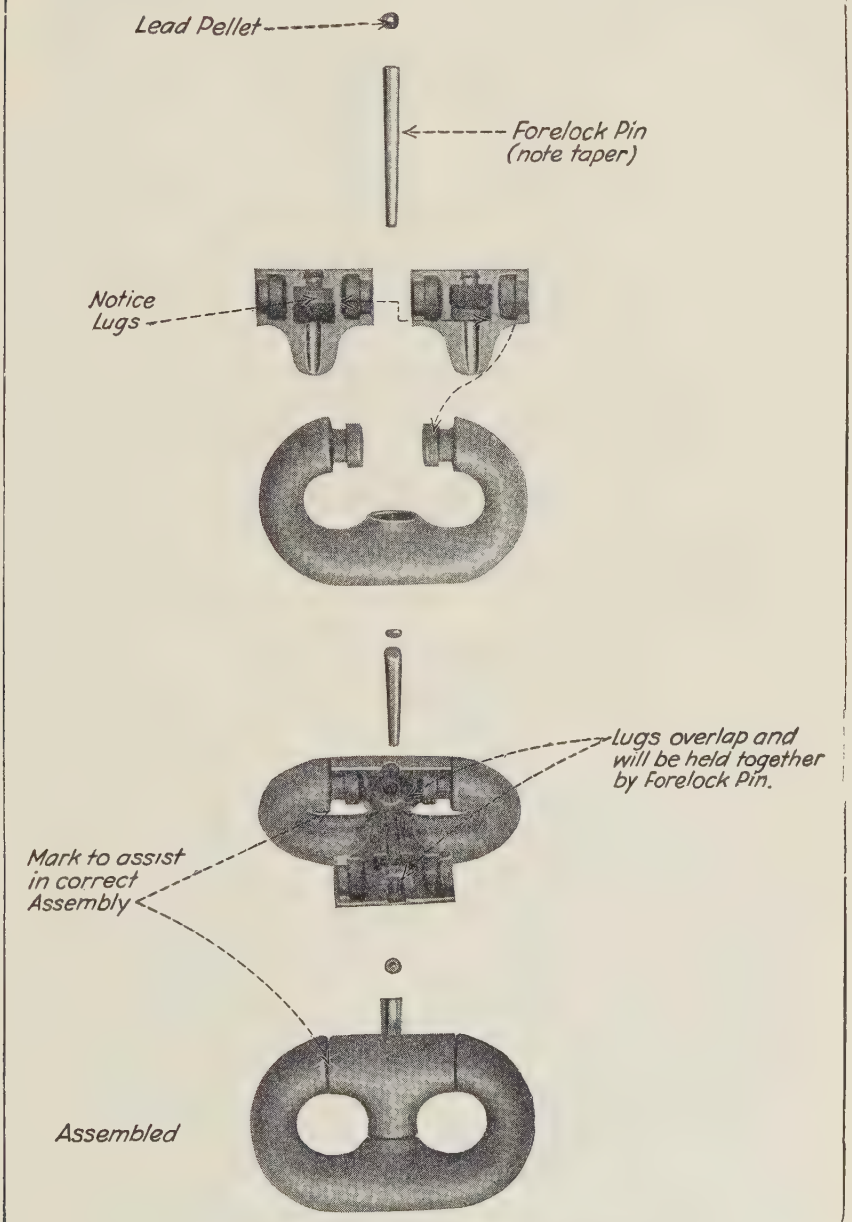


FIG. 3. DIS-ASSEMBLED

NAVY STANDARD KENTER SHACKLE.



DETACHABLE LINK.

Attention is invited to Plates **103** and **105** for study of the various types of links.

"A" links are common links, the ordinary links of the chain.

"B" links are $\frac{1}{16}$ to $\frac{1}{8}$ inch larger wire diameter than A links.

"C" link is a long stud link.

"E" link is an open link.

"F" link is a special link for outboard shot.

"G" link is an open link for outboard shot and takes the bending shackle.

Wire diameter of "A," "B" and "E" links of outboard shots are $\frac{1}{8}$ inch larger than wire diameter of common links of the rest of the chain.

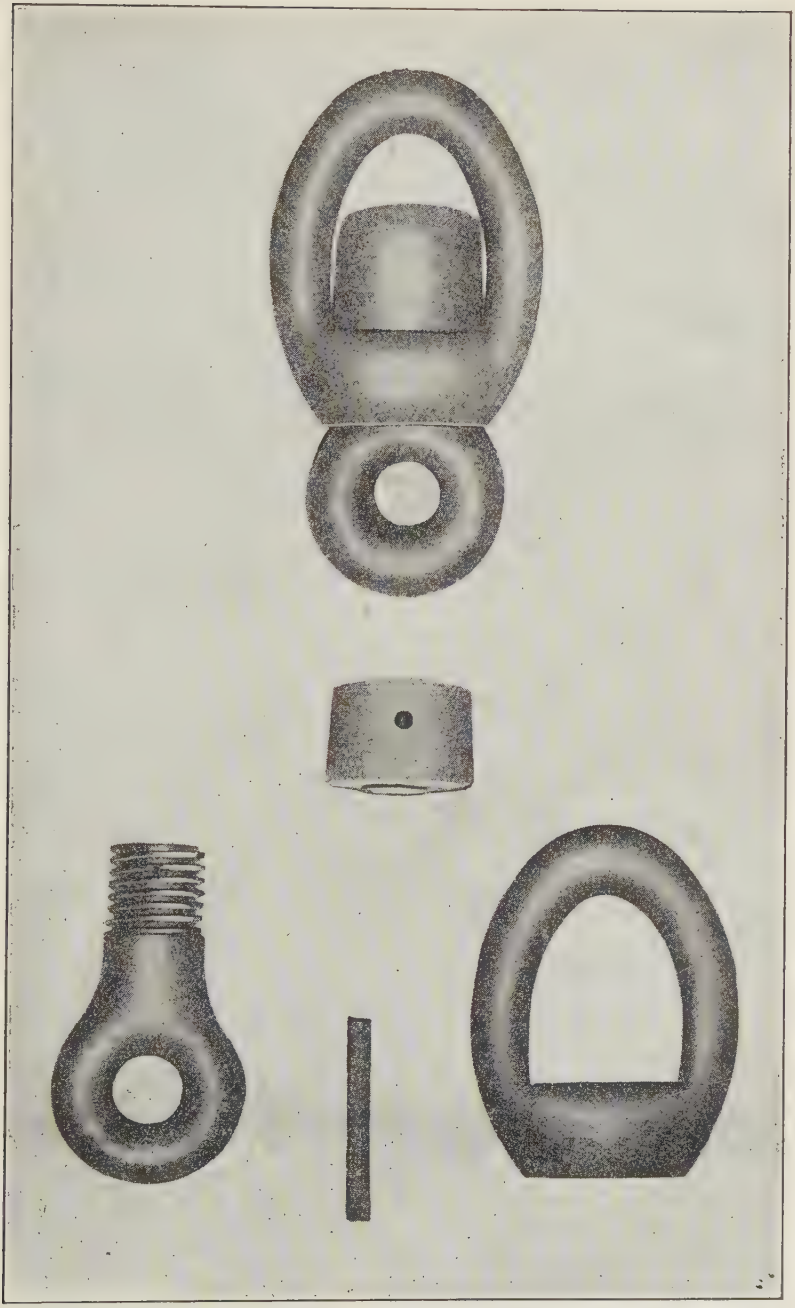
The bitter end of the chain is led over the wildcat and down the chain pipes to the chain locker through a ring bolt as shown in Plate **106** and secured to a pad eye on the bulkhead by means of a slip hook.

To secure properly the bitter end of an anchor in the chain locker, it is imperative that the chain be sent down the chain pipe in the same way it will come over the wild cat when the anchor is let go. To insure this it is necessary that the chain be sent to the chain locker over the wildcat and kept free from turns as it goes down. Unless this be done the chain will kink when running out and may jam in the chain pipe or jump the wildcat when anchoring.

The chain is stowed as it is paid below by "chain tierers," men who tier the chain back and forth in layers upon itself, so that it will be clear for letting go without kinking. In handling heavy chain, chain hooks and tackles are necessary, although in battleships the chain bins are long and narrow so that the chain tends to tier itself automatically. On small chain, it is done by hand. This operation of "tiering" the cable is of very great importance as the cable if paid down rapidly and stowed carelessly is likely to kink in running out and may jam in the chain pipe with disastrous results. Before letting go an anchor make sure that all is clear in the chain locker.

Chain Appendages.

The chief advantages of the Kenter shackle (Plate **100**) and the detachable link (Plate **101**) are:



SWIVEL. (The eye bolt end of swivel goes on away from the anchor in making up the chain—see Plate No. 97.)

STUD LINK CHAIN

FIG. 1

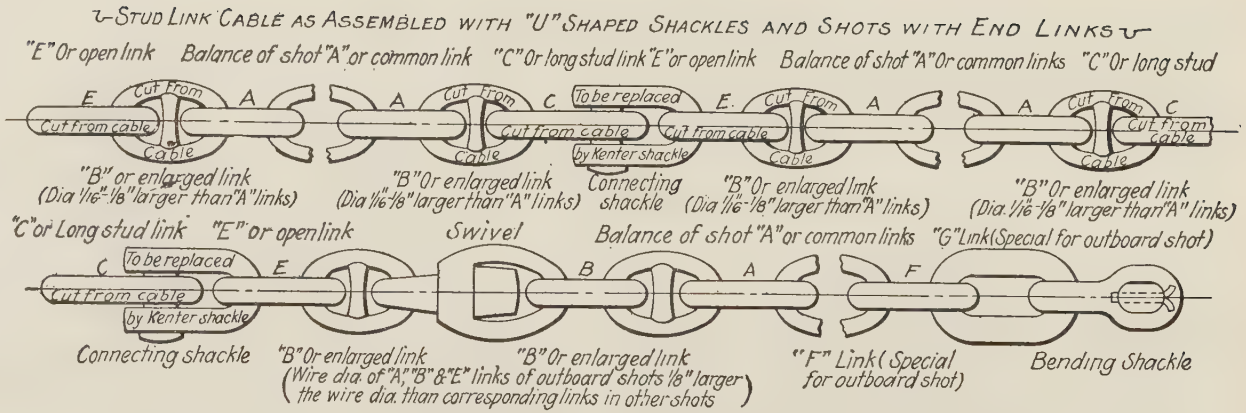
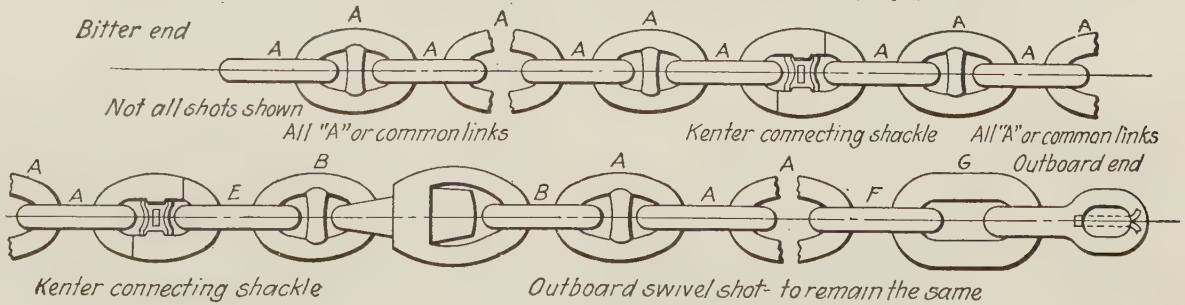

Stud Link Cable as Assembled with "U" Shaped Shackles and Shots with End Links
"E" Or open link
Balance of shot "A" or common link
"C" Or long stud link
"E" or open link
Balance of shot "A" Or common links
"C" Or long stud
Cut from cable
Cable
"B" or enlarged link (Dia 1/16"-1/8" larger than "A" links)
Connecting shackle
To be replaced
Cut from cable by Kenter shackle
"C" or Long stud link
"E" or open link
Swivel
Balance of shot "A" or common links
"G" Link (Special for outboard shot)
Connecting shackle
"B" Or enlarged link (Wire dia. of "A," "B" & "E" links of outboard shots 1/8" larger the wire dia. than corresponding links in other shots)
"F" Link (Special for outboard shot)
Bending Shackle

FIG. 2


Stud Link Cable as Assembled with Kenter Shackles after End Links have been Removed
Bitter end
Not all shots shown
All "A" or common links
Kenter connecting shackle
All "A" or common links
Outboard end
Kenter connecting shackle
Outboard swivel shot- to remain the same

MAKE UP OF CABLES.

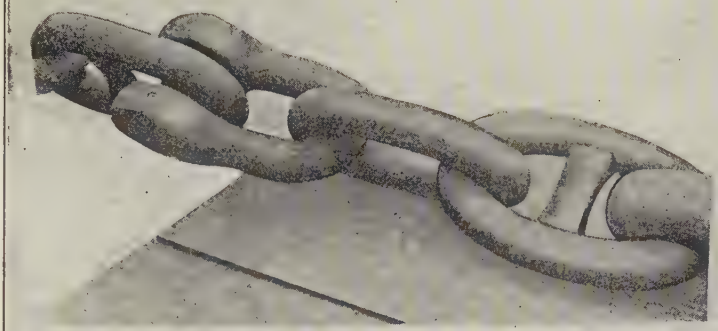


FIG.1. CONNECTING SHACKLE

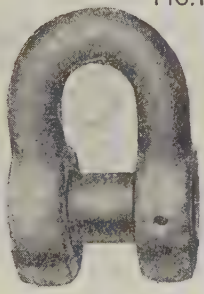


FIG. 2.
CONNECTING SHACKLE

FIG. 3. BENDING SHACKLE

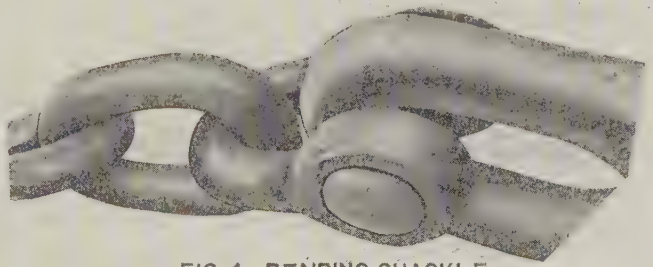
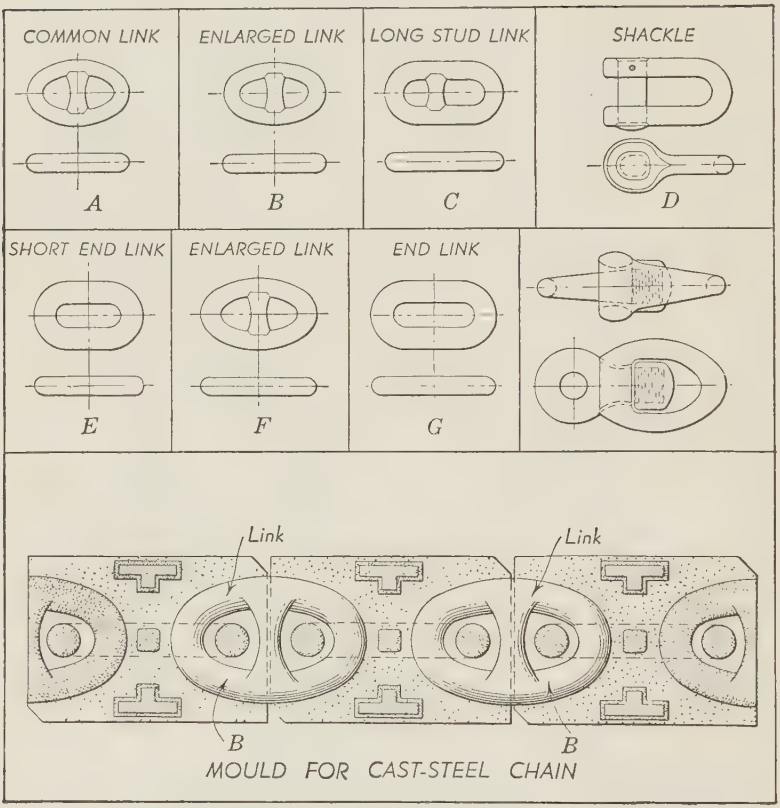


FIG. 4. BENDING SHACKLE

(*a*) They have the same size and shape as the common link and will therefore ride smoothly over the wildcat.

(*b*) The use of long shots (40 fathoms) is no longer necessary. (Page 9).

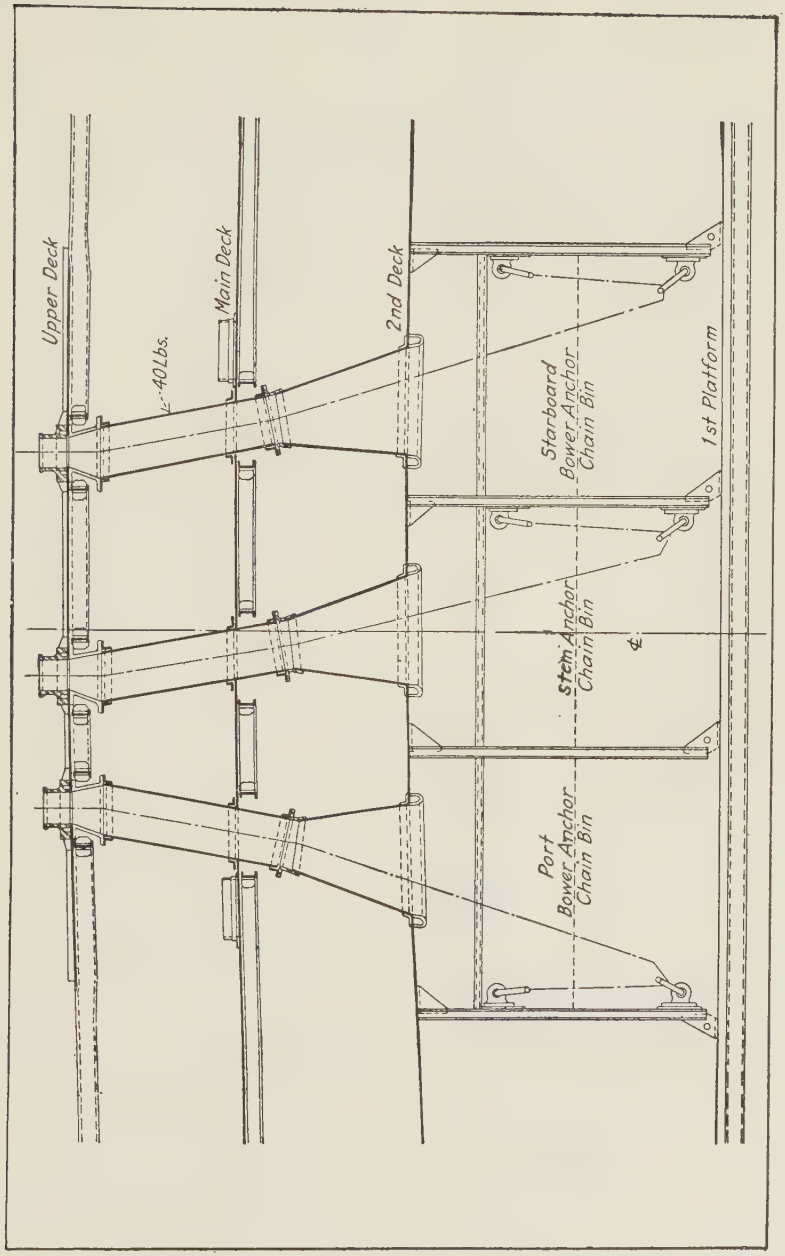
Plate No. 105



(*c*) End links enlarged to take the eye of the old U connecting shackle are no longer necessary.

(*d*) As both ends of Kenter shackle and detachable link are closed, they do not catch on the hawse pipe or deck fittings.

Attention is invited to Plate **100,** from which it will be noted that the shackle consists of interlocking hook-shaped halves held together by a stud and a taper locking pin. The taper locking pin is held in place by a lead plug. One end of each interlocking half



CHAIN LOCKERS.

is finished with a neck and shoulder (male end) and the other with a T-slot (female end). (Fig. 3, Plate **100.**) The T-slot, neck, and shoulder fit together and are slightly tapered to permit of easy assembly and disassembly. The two halves are held in place by a stud, shoulders drop forged and machined on the two half sections, form a key for the stud. These shoulders are staggered and thus, together with assembly marks (an arrow stamped on the stud and one of the halves of the shackle) facilitate the insertion of the stud which can be done by hand pressure, the fore lock pin (taper locking pin) extending diagonally through the shackle.

When assembling Kenter shackles or detachable links in connecting up cables, the machined surfaces should be cleaned and freed of dirt or grit, then slushed with heavy grease or mixture of 40 per cent white lead and 60 per cent tallow by volume. Spares should be kept well greased.

The detachable link was developed as a possible substitute for the Kenter shackle and is intended for use as a connecting shackle.

Never attempt to force a detachable link or Kenter shackle together. They are machined to fit and if properly fitted can easily be assembled by hand pressure alone. If difficulty is experienced try reversing the stud (or coupling). Keep all spares assembled and *do not try to interchange parts.*

Stoppers are of several kinds and called by a variety of names as indicated on Plate **107.** In the Navy the stopper shown in Fig. 3, Plate **107,** is standard and is called "chain stopper." The one immediately abaft the hawse pipe is called the housing chain stopper. The purposes for which chain stoppers are used are:

(*a*) To ride to when at anchor, in addition to the use of the brake band on the windlass.

(*b*) For letting go the anchor more quickly than can be done by the brake band when vessels are anchoring in formation.

(*c*) As an emergency fitting in case the brake band of the windlass should get out of order.

(*d*) To hold a chain cable from running out while it is being taken off the wildcat to permit of another cable being put on for heaving in.

(*e*) To hold anchors snugly in the hawse pipes when housed.

(*f*) To hold an anchor chain when disconnecting for the pur-

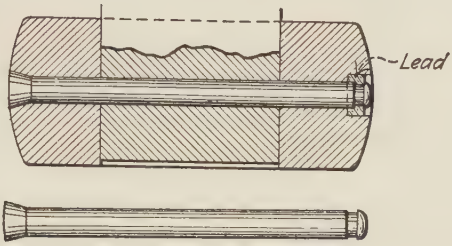


FIG. 1.
DETAILS OF FORELOCK PIN AND LEAD KEYING RING FOR SHACKLES

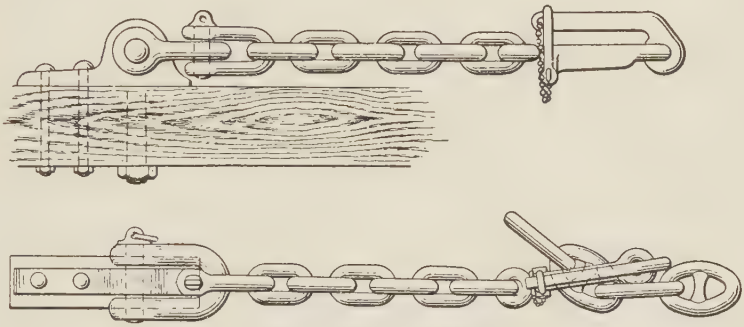


FIG. 2. SLIP STOPPER

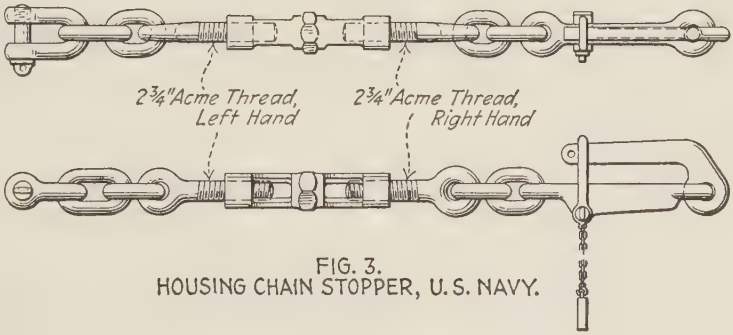


FIG. 3.
HOUSING CHAIN STOPPER, U.S. NAVY.

FIG. 4.
DECK STOPPER, (ROPE)

pose of attaching the mooring swivel. (Preventer hawsers can be used in addition to insure safety).

(*g*) To secure the outboard shot and anchor when anchor chain is used for towing purposes.

The turn buckles should be kept well greased. When using more than one chain stopper on a chain, care should be taken to equalize the strain equally between the several stoppers. This can be readily done by the "feel" of the wrench used in setting up on the turnbuckles. This wrench should be the one designed and furnished for this purpose. No other wrenches should be used at any time on the turnbuckles except the wrench furnished.

Marking Cables.

Cables are marked by turns of wire on the studs of certain links. The number of the link (using studded links only) counting each way from the shackle is used as a marker for that shot (shackle). Thus the five-fathom bending shot and the first shot of chain puts a shackle at twenty fathoms.

20 fathoms, the first studded link on each side of the shackle has a turn of wire around its stud and is painted white.

20 + 15 or 35 fathoms, the second studded link on each side of the shackle has two turns of wire around its stud and the two links on either side of the shackle are painted white.

35 + 15 or 50 fathoms, the third studded link on each side of the shackle has three turns of wire and the three links on either side of the shackle are painted white, etc.

In addition to the marking described the shackles and chain may be painted:

20	fathom	shackle	painted	RED	All other links painted black except as noted in previous paragraph.
35	"	"	"	WHITE	
50	"	"	"	BLUE	
65	"	"	"	RED	
80	"	"	"	WHITE	
95	"	"	"	BLUE	
110	"	"	"	RED	
125	"	"	"	WHITE	
140	"	"	"	BLUE	
155	"	"	"	WHITE	Between the shackles 140-155 all other links painted yellow.

155 to 170 all other links painted RED.

When the chain is running out fast the alternate red, white and blue shackles make identification of shots doubly certain. When the chain has taken charge it goes out too fast to identify the shots of chain marked by white links only, but the colored shackles, if used, can easily be seen and noted. In addition, when the yellow links appear at the wild cat, the man on the brake sets up the brake band taut and the officer in charge of the forecastle stands ready to give the order "Clear the forecastle" in event the chain cannot be brought under control by the time the yellow links appear at the hawse pipe.

III. REGULATIONS RELATIVE TO THE READINESS, CARE AND INSPECTIONS OF GROUND TACKLE.

Navy Regulations require: "The boatswain shall satisfy himself that the ground tackle is always ready for use and in good condition. When at anchor, he should see that nothing interferes with a readiness to veer, slip, or bring to the chain or let go the spare anchor.

"The first lieutenant shall be responsible for the condition of the anchors, chains, and moorings." *The first lieutenant on every ship keeps a complete log of the history of every piece of ground tackle.*

"When moored, the first lieutenant shall keep the executive officer and himself informed of the condition of the hawse and, with the sanction of the commanding officer, shall have it cleared when necessary.

"Before entering port, the first lieutenant shall see that all dispositions for anchoring are made and that all the ground tackle is ready for use."

Since the officer of the deck is "the officer on watch in charge of the ship" and is the officer responsible for the safety of the ship he is vitally concerned with the provisions of the preceding paragraphs.

"When in the vicinity of the land, or upon approaching an anchorage of any kind the commanding officer shall have the cables bent and the anchors ready for letting go."

Anchors, chains, and moorings should be kept in good condition by the ship's force. The chain cables should be overhauled whenever necessary and precautions taken to see that the various

shots are properly marked and in good order. When getting underway, at least two competent observers, preferably petty officers of the artificer branch, should be detailed to examine each link of chain as it comes in for cracks or other defects.

Once each quarter (and more often if necessary) all anchor cables in sizes up to and including 1½ inches shall be ranged on deck and examined throughout their entire length. If necessary they should be scaled, cleaned of rust and other foreign matter. Shackle bolts, fore lock pins, locking pins, lead rings and swivels should be carefully examined for defects.

At least once each 18 months all anchor cable, regardless of size, including all shackles and their parts, and swivels, shall be overhauled and placed in a good state of preservation. The shots of chain shall be shifted to new positions in their relation to the assembled cable to insure even wear through the length of the cable.

If any part of the chain has been reduced by corrosion or wear so that the mean diameter is reduced to 90 per cent of its original diameter, or when the length of six links exceeds the original length of these links plus the wire diameter of the chain in inches due to wear and elongation or a combination of both, that part shall be replaced.

A great many fractures in the *F* and *G* links (Plate **103**) of wrought iron chain have occurred. From the flattening observed on the ends of these links, it appears that these fractures have resulted from the dropping of the *G* link on the jew's harp of the anchor when the anchor strikes bottom.

To prevent such fractures take a length of old manila line and reeve it figure eight fashion through the bending shackle until enough turns have been taken to prevent the *G* link from striking the jew's harp. Thread the ends back through the *G* and *F* links then in and out, over and under the studs of the *A* links for a distance of about two fathoms. The manila takes the shock caused by the end links striking their crowns together when the anchor hits bottom and thus prevents fracture.

This chafing gear should be kept on the outboard shot at all times and renewed when necessary.

It is always good practice to make fast an anchor buoy to the crown of each anchor in making preparations for letting go.

Use a sufficient length of buoy rope to insure the buoy's watching.

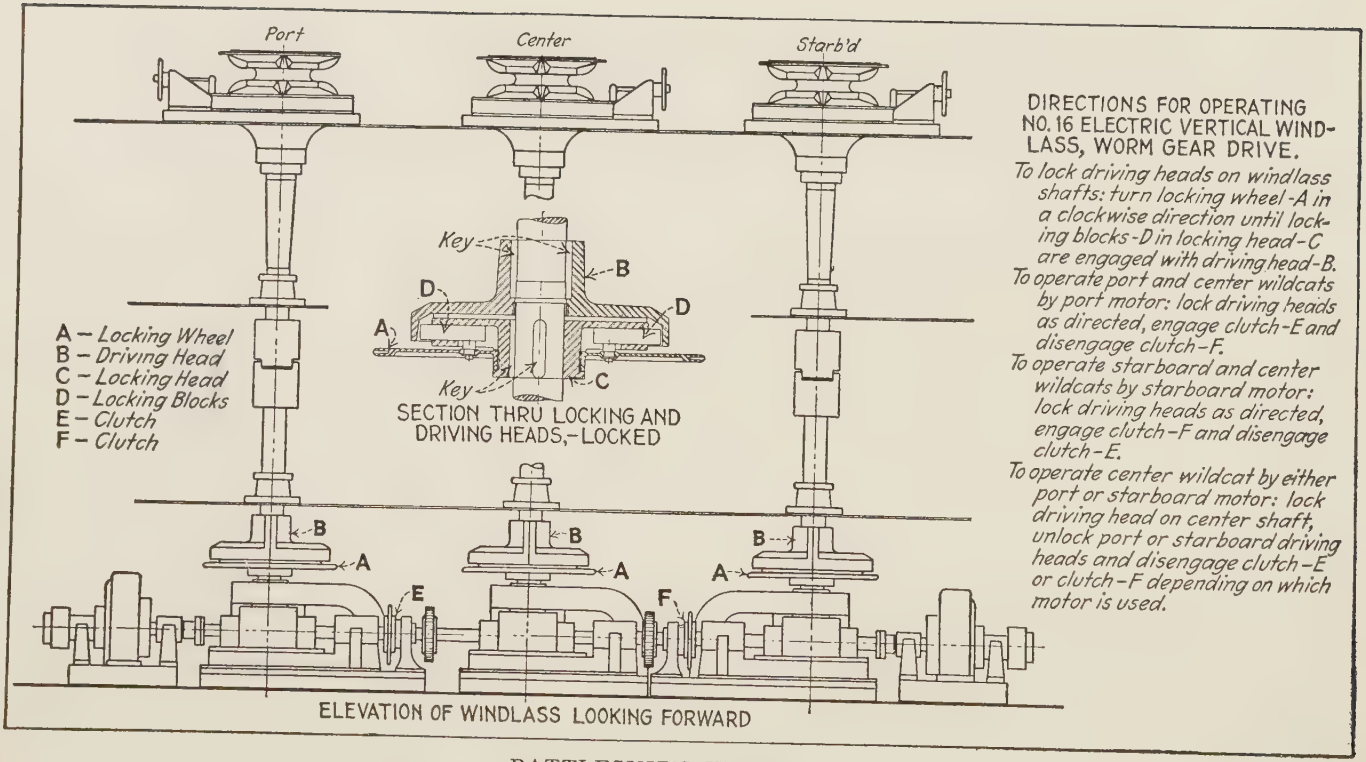
The buoy shows the location of the anchor relative to the ship and is an invaluable aid in recovering a lost anchor.

Windlasses.

There is a great variety in the windlasses used for handling anchors and cables in modern steamers, every firm of shipbuilders having a type of its own. Certain general features, however, are common to them all. A steam-engine or electric motor turns a shaft, either horizontal or vertical, on which is mounted a "wildcat" or "chain-grab," over which the chain passes and by which its links are engaged. The wildcat turns loosely on the shaft, but may be rigidly secured to it by some form of connection, and much of the individuality of different types of windlasses lies in the nature of this connection. The wildcat is secured to the shaft for heaving the chain in or out, but is disconnected in veering chain and in riding by the wildcat; being controlled, when so disconnected, by a friction brake.

Plate **108** shows the type of electric windlass installed in the later battleships and Plate **109** the steam windlass for the older type of destroyers. Plate **110** shows an earlier type of windlass (horizontal) carried by some of the old battleships. The drawings have been prepared with a view to illustrating the details of the interior mechanism, especially the arrangements for locking and unlocking the wildcats.

The type of windlass installed in Light Cruisers, CL4 to 10, uses a vertical steam engine and worm drive to two vertical wildcat shafts. An entirely new type of windlass has been developed for the new cruisers and the Aircraft Carrier Ranger. In this design worm reduction gears, which often show excessive heat and cutting from high pressure involved, are avoided and spur gearing, with hydraulic variable speed gear transmission from a constant speed motor, used. At low speed hoisting great torque is available for breaking out the anchor. This is limited only by the relief valves which are so set as to prevent overstraining the chain.



DIRECTIONS FOR OPERATING NO. 16 ELECTRIC VERTICAL WINDLASS, WORM GEAR DRIVE.

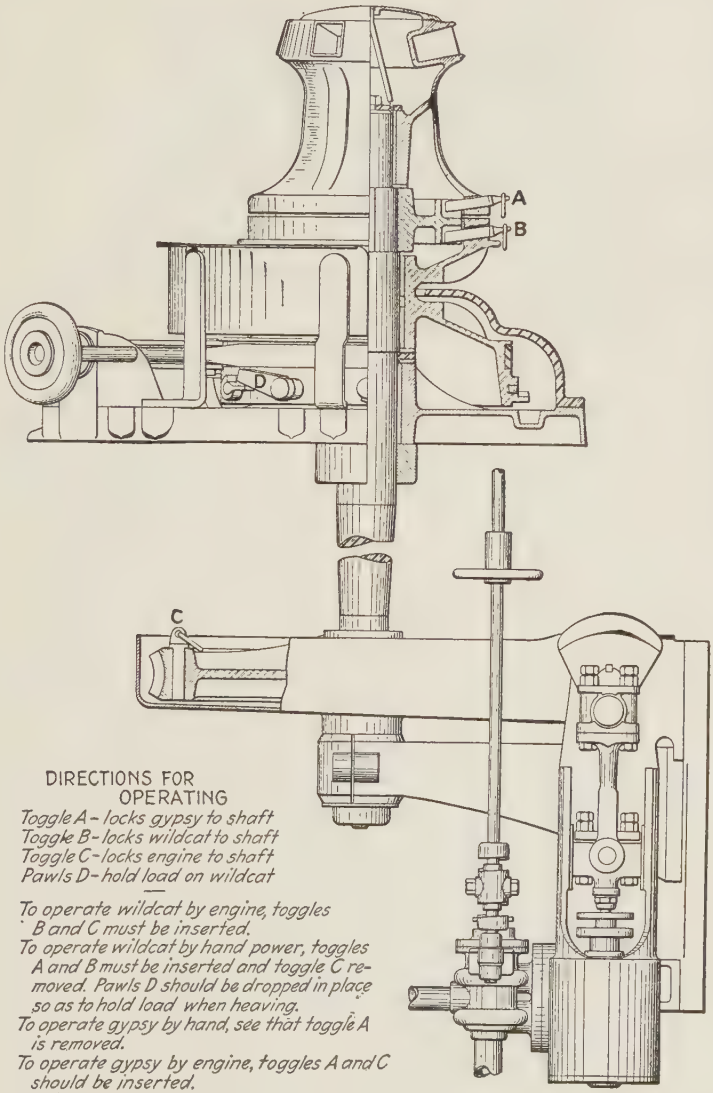
To lock driving heads on windlass shafts: turn locking wheel-A in a clockwise direction until locking blocks-D in locking head-C are engaged with driving head-B.

To operate port and center wildcats by port motor: lock driving heads as directed, engage clutch-E and disengage clutch-F.

To operate starboard and center wildcats by starboard motor: lock driving heads as directed, engage clutch-F and disengage clutch-E.

To operate center wildcat by either port or starboard motor: lock driving head on center shaft, unlock port or starboard driving heads and disengage clutch-E or clutch-F depending on which motor is used.

BATTLESHIP'S WINDLASS



DIRECTIONS FOR OPERATING

Toggle A - locks gypsy to shaft
Toggle B - locks wildcat to shaft
Toggle C - locks engine to shaft
Pawls D - hold load on wildcat

To operate wildcat by engine, toggles B and C must be inserted.
To operate wildcat by hand power, toggles A and B must be inserted and toggle C removed. Pawls D should be dropped in place so as to hold load when heaving.
To operate gypsy by hand, see that toggle A is removed.
To operate gypsy by engine, toggles A and C should be inserted.

DESTROYER'S WINDLASS.

Directions for Keeping Windlass in Order.

Keep all bearings well oiled.

Oil holes, pressure lubricating fittings and automatic lubricators are provided for lubricating the bearings and moving parts. They should be kept free from dirt and regularly inspected. Use none but the best sperm oil for bearings. Castor oil with a small mixture of white lead or extra heavy high grade oil with the addition of white lead to the oil mixture should be used for lubricating the worm gearing to prevent cutting and heating.

The windlass should never be run without the gear teeth and worm being well slushed with black lead and tallow, a can of which is sent with every machine, and which should be replaced with more of the same material.

When the windlass is not in use, the cylinders and steam-chest drips should be left open, so as to drain all the condensed steam from the engines.

When starting a windlass for the first time it should be handled carefully and under the direction of an experienced person. Run it at first without any load until the bearings, worm, and worm-gear teeth are perfectly lubricated.

Letting Go.

In modern ships with heavy ground tackle, the anchors are commonly housed in the hawse-pipe and secured by chain-stoppers which engage the chain by a slip or "pelican" hook (Plate **107**). In preparing to let go make sure that the anchor is not stuck in the hawse pipe, then all but one of these stoppers are cast off and the windlass brake slacked, leaving the anchor hanging by one chain stopper immediately abaft the hawse pipe.

If the drift between the hawse-pipe and the chain-locker is considerable, it is well to rouse up a few links of chain, lightening the slack forward to a point just abaft the stopper.

Care must be taken that all is clear below decks and in the chain-locker. A reliable man should be stationed near the locker and made responsible for this.

To let go, the link of the chain stopper is knocked loose with a sledge.

Always bear in mind that the anchors may be *unexpectedly* required when on soundings, in narrow channels, restricted

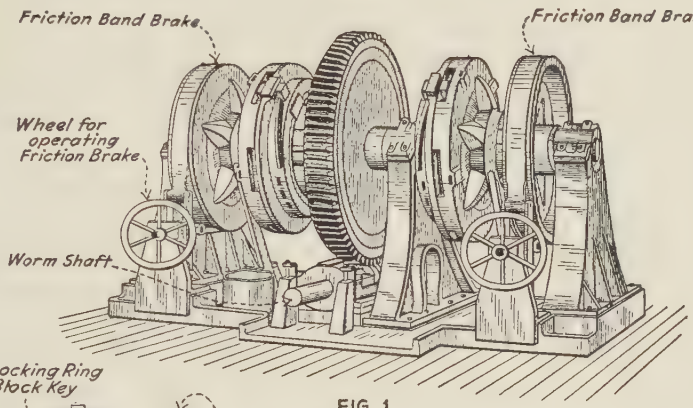


FIG. 1

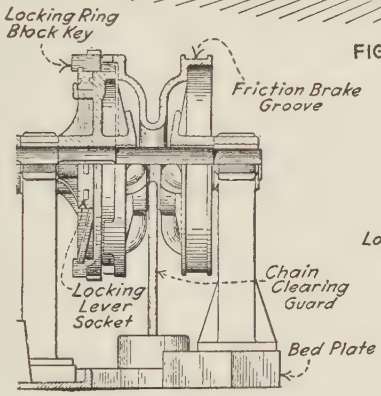


FIG. 2

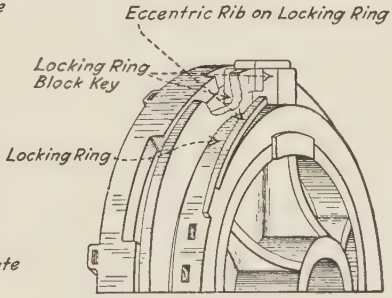
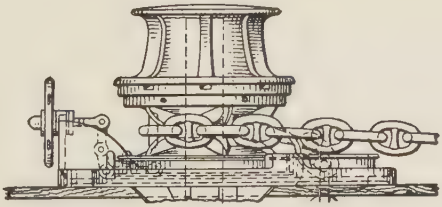


FIG. 3
LOCKING GEAR

HORIZONTAL WINDLASS
(EARLY TYPE)



VERTICAL WINDLASS
(EARLY TYPE)

WINDLASS ON OLDER BATTLESHIPS.

waters or working around docks, etc. They should be ready for *instant* use and may save worry and trouble.

As the anchor may hang in spite of the slack links above mentioned, it is well to have an anchor-bar at hand for shaking up the chain, especially if anchoring in formation when a delay of a few seconds may be serious. In some vessels, as the *Texas*, where the anchors may jam in the hawse-pipes, it is good practice to ease out the anchors, when they may be called upon for an emergency.

Where the anchor is carried on a bill-board (Plate **98**), the lashings used in securing the anchor for sea must first be cast off, leaving the anchor hanging by two chains, each secured at one end by a lashing and at the other by a link which engages a trigger-bar, by tripping which both chains are released simultaneously.

In some cases anchors carried on a bill-board are lifted by a "fish-tackle" hooked to a swinging davit and lowered until they hang by the cable from the hawse-pipe, from which position they are let go from a stopper exactly like the housing anchors already described.

The anchor should always be let go with the ship moving slowly, either ahead or astern, to avoid paying the cable down on top of the anchor.

With the old-fashioned anchor, it is generally better to be going astern, at least when anchoring head to tide or wind, as otherwise the bight of the chain is likely to foul the anchor as the ship drops back. If conditions are not such that she will drop back over the anchor, this point is of no consequence; and with a patent anchor (which has no projecting fluke to be fouled) it is not important in any case. There are some advantages about letting go with headway on, especially when it is desired to anchor at a definite point—standing in, for example, on a given bearing and anchoring when another bearing is on. It is much easier to do this with the ship going ahead and thus under control; and no other way is practicable if it happens that the line on which the ship runs in is more or less across the wind or tide.

Where it becomes necessary to anchor in very deep water, it is absolutely essential that the ship should be going dead slow. If several ships are anchoring in formation, they should anchor in

succession, not simultaneously. As the anchorage is approached, at very slow speed, the anchor may be lowered gradually until it is within a few fathoms of the bottom, and then let go, only enough headway being maintained to avoid paying the chain down on top of the anchor. The details of handling the windlass for anchoring in this way will vary with the type of windlass used, but it will be found that even where the ship is dead in the water, and where the anchor is let go with only a few fathoms of drop, *the weight of the chain alone will cause it to run out very violently.* In extreme cases, where the depths run, as in several Puget Sound ports for example, up to 40 and 50 fathoms, it may be advisable not to "let go" at all, but to "back out" the chain by the windlass engine, until the anchor is on the bottom and the necessary scope of chain out. The *usual* practice is to ease down the anchor to within five to twenty fathoms from the bottom *at the proposed anchorage.*

In the case of a number of vessels anchoring together in formation, it is essential that all should let go while going ahead with some speed, and it becomes a matter of considerable interest to know what speed is safe under these conditions. It will be found that almost any ship with reciprocating engines or electric drive, running at a speed of four or five knots with steam available for twelve knots, and backing with full power as the anchor is let go, can be brought up at 45 fathoms without undue strain on the cable. With turbine engines even this speed is too high because of the limited power available for backing. Here the maximum permissible speed is believed to be not in excess of three knots.

If obliged to let go at a higher speed, or if for any reason it does not seem safe to check her with so short a scope, *the chain should be allowed to run until she loses her way sufficiently to make it safe to snub her.* There is no great harm in running out 75 or even 90 fathoms of chain and afterward heaving in to a shorter scope; and it should be remembered that even in cases where the headway has to be checked by bringing up on the chain, the danger is less with a long scope than with a short one.

The danger connected with letting go while under considerable headway is often overlooked, for the reason that *the damage resulting from it does not necessarily show itself at once.* The excessive strain may distort and weaken the links of the cable,

without actually parting them. The result is that the cable may give way at some time under a comparatively moderate stress.

This can be illustrated by an example:

Suppose it is necessary to stop a ship displacing 27,000 tons, traveling at 4 knots, to stop in 100 feet. The formulae for the "Force" to perform this feat is

$$F = Ma = \frac{W}{g} \times \frac{V^2}{2S}$$

Where F = force; M = Mass = weight in pounds divided by the acceleration of gravity; V = velocity in feet per second at the time the force F is applied; S = distance in feet in which it is desired to bring the body to rest. Substituting in the formulae

$$F = \frac{2240 \times 27{,}000}{32.16} \times \left(\frac{6080 \times 4}{3600}\right)^2 \times \frac{1}{2 \times 100} = 429{,}000 \text{ pounds.}$$

If this force does not exceed the working stress of the chain, the chain could safely be used to snub the ship to a stop. If the force were greater than the working stress of the chain, the ship could be stopped and it might be that no deleterious effects would be noted until at some later date and under comparatively small strain the chain parted due to the "stretch" it had received by the previous snubbing.

Weighing.

In heaving in, the windlass and cable can be relieved of considerable strain by a judicious use of the engines and rudder. To do this the forecastle party must keep the bridge fully informed as to how the chain "tends" or "grows"; whether the chain is "taut" or "slack"; when the anchor is at "short stay"; when the chain is "up and down"; when the anchor is "aweigh." As the anchor is hove in the report is made to the bridge "Anchor in sight, sir," "Clear or foul anchor," as case may be; "Anchor is up, sir." The Captain will then direct "Secure the anchor" or "Get the anchor ready for letting go."

In case the chain gets across the bow, it may be cleared by stopping the windlass and going astern a few turns with the proper engine.

If there is much tension on the chain when a "U"-shaped shackle or swivel comes to the wildcat, there will be trouble from the slipping of the chain, as swivels and "U"-shaped shackles are necessarily larger and longer than the links, and cannot take the lugs of the chain-grab so securely. This trouble may always be expected when the depth of water is such that a swivel or a shackle is on the wildcat in breaking ground or after the anchor is aweigh. It may be met by clapping a "hook-rope" on the cable at once and taking this to the "gypsy" or the capstan. If neither of these is convenient, a deck tackle may be hooked on and well manned. If the drift between the windlass and the locker admits of such a thing, a tackle abaft and below the wildcat is very helpful, tending not so much to relieve the stress as to jam the chain down into its place on the wildcat, and so prevent slipping. In ships where this difficulty is to be anticipated, it should be prepared for as part of the regular preparations for getting underway.

Foul Anchor.

The old-fashioned anchor often comes up with one or more turns of the cable around the stock, the shank, or the flukes.

The conditions here may vary so widely that only very general rules can be laid down for dealing with them. The anchor is usually hoisted to the davit-head and cleared by dipping the chain, unshackling if necessary. Slack chain is of course paid out, and the bight hung by slip-ropes to take the weight. If the tackle cannot be hooked in its proper place, it must be hooked to a strap. Slew-ropes on the stock are helpful in clearing the turns.

If the anchor comes up crown first, a strap is used around the arms and shank, and the crown is run up to the davit head. It may be hung there by a hawser, the tackle shifted to the balancing link, and the anchor capsized by slacking the hawser and hauling on the tackle.

Sometimes a turn around the stock can be cleared by hooking the tackle with a turn in the opposite direction to that of the chain, while the anchor is at the hawse-pipe. As the chain is surged and the tackle run up, the anchor slews and the chain falls clear.

In all cases of unshackling, a hawser should be secured to the ring of the anchor, as something may give way when least expected. Much labor in lifting and dipping the chain may be saved by the use of two pendants, the anchor hanging by one, as usual, the bight of the chain by the other. The bight being thus held, the anchor is lowered, slewed clear of the cable, and again run up. By this method, the anchor is dipped, instead of the chain, and the heavy work of clearing is all done by the winch instead of by hand.

Whenever possible, the anchor should be landed in its place and secured before the work of clearing begins. Where circumstances do not admit this, it should at least be run well up to the bow and above the rail, where it can be reached conveniently. An anchor bar or small "crowbar" is very handy in opening out the parts of the chain when jammed one upon another.

Perhaps the most difficult case of fouling that can arise is one in which the chain is found hitched around the stock or the arm, with the hauling part coming out from the inside of a round turn, and with this turn jammed hard upon it. Here it is particularly important to get the anchor close in to the forecastle. The parts may be pried apart a little at a time by means of a small flat-pointed iron bar, and the hauling part dragged through the bight by a jigger on the end of the stock, the amount gained at each fleet of the jigger being lashed before the strap is shifted for a new pull. In this way, inch by inch, enough slack is accumulated on the bight to admit of lowering it over the end of the stock or fluke, where it will fall clear.

While modern double-fluke anchors are much less likely to foul than the old type, they occasionally give much trouble in this way and a ship whose anchors house in the hawse-pipes may be greatly embarrassed by the lack of facilities for lifting the anchor to a point where it can be hung securely and where the chain can be handled conveniently.

As a rule, the best that can be done in such a case is to hang the anchor by straps and stoppers, and send men over the bow to clear the chain as best they may, assisting them from the forecastle by lines and tackles to take the weight of the bight. A davit which can be shipped above the hawse-pipe, plumbing the anchor as it hangs outside, is very helpful here.

Under conditions such that the anchor may be expected to

foul, it is a good rule to "sight" it frequently; and indeed this is advisable under any conditions when a ship remains at single anchor for a long time. It is especially important if, after lying for some time under circumstances which make it probable that the anchor may be foul, bad weather is found to be approaching. For sighting, the anchor may be lifted just far enough to be seen, or, what is usually more convenient, it may be weighed completely and another anchor let go when the cable of the first one is "up and down"; that is to say, just before the first anchor is broken out from the bottom.

Anchoring by the Stern.

It is often convenient and sometimes necessary for a vessel to anchor by the stern. For this an anchor of moderate size is usually sufficient, and it is an excellent plan to carry such an anchor at the stern ready for letting go in a hurry. If a shackle is kept at hand, and if a thimble is turned into the end of the best wire hawser, this hawser can be shackled up to the anchor and all made ready for letting go in a very short time. The ability to anchor in this way is so valuable under many circumstances, that it is surprising how rarely it is thought of or foreseen. In coming to, in a narrow or crowded anchorage with a fair tide, where perhaps difficulties are found which had not been anticipated, it might be of the greatest possible value. So, too, in going alongside a dock or into a slip, with a fair wind or tide, as it is sometimes necessary to do, a stern anchor such as has been described (not a kedge) might make a perfectly simple situation out of one which would otherwise be very difficult.

If it becomes necessary to use a *bower* anchor over the stern, the simplest way to deal with the situation is to ease the anchor down until it hangs outside the hawse-pipe with its ring just clear, at the same time making preparations for unshackling at the five-fathom shackle, and holding the chain, outside of this shackle by a good chain stopper. Pass the end of the best wire line out through the stern chock, take it forward and shackle securely to the ring of the anchor. In this, as in all other cases where the anchor is to be used without its own cable, it is very important to use a "weighing line" and buoy-rope on the crown of the anchor. (Chapter XII, Sec. 2.)

Let go when ready by knocking off the link of the chain stopper.

If it is desired to ride by the bower cable rather than by the wire line, pass the line forward from the stern-chock as before and stand by to shackle it to the chain when ready. Run in at slow speed to the point where the anchor is to be placed, keeping the ship under control, let go, and veer to 60 or 90 fathoms as desired, bringing-to with the shackle well inside. Pass the end of the wire line inside the hawse-pipe. Stopper the chain well, and bend on an easing-out line just forward of the shackle. Take the easing-out line to the capstan and take the strain on it. Shackle the wire to the shackle of the chain. Unshackle the chain. Take the after end of the wire line to the after windlass. Ease out forward, heave in aft. Let the easing-out line go with the chain, standing clear of the end. Heave the line and cable aft, and secure.

In many harbors, a swell sets in on the beam of vessels riding to the wind, causing them to roll incessantly. In such cases, a stream anchor planted off the bow, with a line from the quarter, admits of springing around, head to the swell. In the tropics, a similar plan adds much to the coolness of the ship by bringing the wind abeam.

When anchoring in a narrow river or harbor where there is little room for turning and where occasion may arise for leaving hurriedly, it is well to keep a hawser triced up along the outside from the warping chock on the quarter to the hawse, ready for clapping on the chain. If an emergency arises while the ship is heading in, the spring is bent to the cable, and the cable unshackled. The ship then swings, the line is buoyed and cast off and all is clear for standing out.

Riding to a Single Anchor.

Ships usually ride to a single anchor. They moor only in waters where it is necessary to restrict their swing. (See Mooring.)

So long as ordinary conditions of wind and tide prevail, the rule "Use a scope of 5 to 7 times the depth of water" is an excellent one. But there are times when ships are forced to ride out gales in exposed anchorages. It is under these circum-

stances that thumb rules fail and a thorough understanding of the forces acting on the anchor chain is necessary.

It has long been a universal rule among seamen that the longer the scope of chain the more easily a vessel rides to a gale and the less danger there is of dragging her anchor. Let us examine this situation and then draw our conclusions.

When a ship is riding to her anchor the chain hangs in a catenary.

From the equation of the catenary:

I. $T = H + wy.$

II. $\left[y + \frac{H}{W} \right]^2 - S^2 = \left[\frac{H}{w} \right]^2.$

y is the ordinate.

T is the tension in the chain at any point.

H is the horizontal tension at any point and it may be well to stress the fact that the horizontal tension is constant for all points of the catenary under a given condition.

w is the weight of the chain per unit length.

S is the length of the chain.

Since chain has physical properties of tensile strength and elastic limit that affect the working stress and breaking stress of the chain, the question will at once arise as to how much chain is it safe to veer in a given depth of water in order that the physical properties of the chain will not be violated. If we say y = distance from hawse-pipe to bottom and express this as $(D + d)$ where D equals the depth of water in fathoms and d is the height in fathoms of the lip of the hawse-pipe above the water's edge, w is the weight of chain per fathom. T is the tension on the chain. Equation (I) shows that T will be greatest under any conditions at the lip of the hawse-pipe. If we use a factor of safety of 4, then T (max) must be equal to the breaking stress of the chain divided by the factor of safety. When one stops to consider the yawing and pitching of a ship in riding out a gale, a factor of safety of 4 is reasonable. Taking equation II

$\left[y + \frac{H}{w} \right]^2 - S^2 = \left[\frac{H}{w} \right]^2$ and rewriting it to obtain an expression

for S.

$$S = \sqrt{y\left[y + \frac{2H}{w}\right]}$$

Attention is invited to the Appendix, Tables XXV and XXVI, showing the drag on a ship due to the wind and the tide.

If T is the breaking stress of the chain

$\frac{T}{4}$ is the maximum stress that is to be allowed in the chain.

$$\frac{T}{4} = H + wy \text{ (equation 2)}$$

or $$H = \frac{T}{4} - wy,$$

and $$2H = \frac{2T}{4} - 2wy = \frac{T}{2} - 2wy.$$

Substituting this expression for $2H$ in the equation

$$S = \sqrt{y\left(y + \frac{2H}{w}\right)} \text{ we get } S = \sqrt{y\left[\frac{T - 2wy}{2w}\right]}$$

Now if we substitute $y = D + d$ in this equation

$$\sqrt{(D + d)\left[\frac{T}{2w} - (D + d)\right]}$$

Knowing the tensile strength of the chain and applying the principles above described, a table of length of chain to which it is safe to veer in various depths can be obtained. Such a table is given.

Depths in Fathoms.	Length in Fathoms, Wrought Iron Chain.	Length in Fathoms, Cast Steel, Forged Steel or Die-locked Chain.
7½	79	107
10	87	119
15	102	140
20	115	157
25	126	173
30	137	188
35	146	200
40	155	213

If the lengths indicated in the table are exceeded, there is the danger that the chain will part before the anchor drags.

The length given in the table takes into account the allowed working stress of the chain, the depth of the water, and the weight of the chain. And since the scope of chain used in the table was obtained from the formula for a catenary under the condition in which the chain pulls horizontally on the anchor at the jew's harp when the tension in the chain at the hawse is equal to the working stress, it follows that a safety factor is introduced by not exceeding the scopes of chain as tabulated. For in a given depth and using the scope of chain tabulated for that depth, an increase in the forces acting on the ship will cause an increase in the tension acting in the chain which will lift the chain so that the pull of the chain at the jew's harp will no longer be parallel to the bottom (horizontal) but have a vertical component tending to break out the anchor and the anchor will drag before the chain is seriously strained or broken.

To ride out a severe storm back the first anchor by dropping a second and ride to two anchors using the tabulated scope of chain on the first anchor, or drop the second anchor under foot so as to be ready to veer chain on that anchor should the first anchor drag. In extreme cases steam to the anchors.

CHAPTER X.

MOORING.

A vessel is moored when she has two anchors down at a considerable distance apart and with such a scope of chain on each that she is held with her bow approximately midway between them.

A vessel secured in such a manner may head in any direction, but will tend to swing about her stem as a pivot. The amount that she deviates from this will depend upon the tautness of the moor.

Vessels moor in congested harbors, in harbors with limited space for swinging with wind and tide, and in harbors where regulations require vessels to moor. When it is not necessary to moor, it is more practicable to use one anchor with a good scope of chain which can be veered if necessity arises.

In mooring it is necessary to consider the set of the current in order to lay the line of anchors parallel to its direction. If this is not done the vessel will ride to a span (see chapter on Mechanical Appliances; the span), and it can happen that the strain on each chain will be greater than if the ship were riding to a single anchor.

Should a vessel, moored, be struck by an unexpected gale and ride to an open hawse (span) it is imperative that she veer to as long a scope as may be safe. If such a situation is foreseen at the time of mooring and no mooring swivel is used, the anchors should be laid out closer together (slack moor) than otherwise. Indeed, there is always an advantage in mooring with a rather short scope on each chain; for if a gale comes up along the line of anchors it is practicable to veer the riding chain and drop to leeward, bringing both anchors ahead. Should the ship ride to an open hawse the closer the anchors are together the less will be the strain on each chain.

When a mooring swivel is used it is impossible to veer both chains.

DIP ROPE
1½-inch, 14 fms.

MOORING
SWIVEL

CLEAR-HAWSE PENDANT
2¾-inch, 15 fms.

CLEAR HAWSE GEAR

Note.—The Clear-Hawse Pendant shown above is made of wire and not chain.

Gear Used in Mooring.

The *Mooring Swivel* is a swivel of special design intended to reduce the danger of foul hawse and the necessity of tending ship. (Plate **111.**)

The *Clear-hawse Pendant* is made up of a length of open-link chain about one-half the size of the anchor chain, fitted at the outer end with a pelican hook and the inner end with a shackle and thimble into which is spliced about thirty fathoms of type "E" wire rope of sufficient size for the purpose. (Plate **111.**)

The *Dip Rope* is a manila or wire rope having at one end an eye splice with a thimble into which is inserted a dip shackle large enough to engage a link of the chain cable.

A *Preventer Hawser* of manila (to be bent on the chain above or below the pelican hook of the clear-hawse pendant) is a hawser of sufficient strength to take the strain in case the clear-hawse pendant carries away or to relieve the strain on the clear-hawse pendant.

An *Easing-out Line* on the chain is for easing out the chain after unshackling.

Spare connecting shackles and unshackling kit are also provided.

Deck tackles, hook ropes, chain hooks, straps, rope for lashings, tap mauls, chain stopper wrenches, cable jack, etc., must be available.

Information Necessary for Mooring.

Before making a moor it is desirable to establish a Bench Mark for letting go the second anchor. To establish such a Bench Mark the Drift must be known.

Drift: That amount of each anchor chain that is necessarily held on deck with which to work (to stopper the chain, break the chain and connect that chain to the mooring swivel). Total Drift is the sum of the amount of each chain that is necessarily held on deck with which to work (to stopper both chains, disconnect both chains and connect each chain to the mooring swivel).

Drift should be made as small as practicable.

To find the horizontal distance from the center of the berth to the first anchor and to establish the bench mark for letting go the second anchor, the horizontal distance of each anchor from the center of the berth must be computed.

$a =$ horizontal distance from anchor to center of berth.

$d =$ height of outboard lip of hawse-pipe above bottom (final position of mooring swivel just outside the hawse-pipe).

$S =$ scope of chain from outboard lip of hawse-pipe to anchor. Before the mooring swivel is connected to a chain,

$S =$ Final Scope $-$ Drift.

$$a = \left[\frac{S^2}{d} - d\right] \tanh^{-1} \frac{d}{s} \qquad \text{I}$$

An approximation, close enough for practical purposes, of the horizontal distance between an anchor and the center of the berth can be obtained by

$$a_1 = \sqrt{S^2 - d^2} \qquad \text{II}$$

$a_1 =$ the approximate horizontal distance between an anchor and the center of the berth.

Example:

A ship is going to make a flying moor in 13 fathoms of water, 50 fathoms of chain on each anchor. Drift on lee chain 5 fathoms. Drift in riding chain 4 fathoms. Outboard lip of hawse-pipe 2 fathoms above water's edge. Final position of mooring swivel to be at outboard lip of hawse-pipe.

$S = 50 - 5 = 45$ fathoms on the anchor.

$d = 13 + 2 = 15$ fathoms.

Using I, $a = \left[\frac{45 \times 45}{15} - 15\right] \tanh^{-1} \frac{15}{45}$

$a = 41.58$ fathoms horizontal distance between lee anchor and center of berth.

Had II been used

$a = \sqrt{45^2 - 15^2} = 42.42$ fathoms.

The percentage of error resulting from the use of the approximate formula

$$\frac{(42.42 - 41.58)}{42.42} 100 = 1.98\%.$$

As the ratio $\frac{S}{d}$ increases the percentage of error resulting from the use of II rather than I will decrease. For this reason II will be used.

Horizontal distance from center of berth to second (riding) anchor.

$S = 50 - 4 = 46.$

$a_1 = \sqrt{46^2 - 15^2} = 44.62$ fathoms.

To find the bench mark:

The distance between the two anchors will be

$$42.42 + 44.62 = 87.04 \text{ fathoms.}$$

With this distance as a_1, in II, solve for S;

$$S = \sqrt{87.04^2 + 15^2} = 88.38 \text{ fathoms.}$$

When the second anchor is let go 88.38 fathoms on the lee chain must be at the outboard lip of the hawse-pipe. The next shackle in the chain is at 95 fathoms.

Therefore, measure back (95 — 88.38) or 6.62 fathoms from the outboard lip of the lee hawse-pipe and make the bench mark on deck. When the 95-fathom shackle on the lee chain is at this bench mark (and the lee chain properly laid out) let go the second anchor.

To determine the proper bearings for letting go the first anchor the navigator must know the scope of chain and drift to be used on each anchor. With the scope minus the drift as the hypotenuse and the vertical height of the mooring swivel above the bottom as a side of a right triangle find the horizontal distance between the first anchor let go and the center of the berth assigned. To this distance add the distance between the pelorus and hawse-pipe (taking care to keep all distances in the same units). With this sum as a radius and the center of the berth to be occupied as a center, draw a circle. When bearings indicate that the bridge is on this circle notify the captain that the ship is in position to let go the first anchor.

The bridge should give the orders to let go the first anchor; the officer in charge on the forecastle orders the second anchor let go when the anchor chain is properly laid out and the proper shackle is at the bench mark.

Ways of Mooring.

There are two ways to moor: the ordinary moor and the flying moor.

In the ordinary moor the ship stands against the current (wind) to the proper position and lets go the first anchor, *which must always be the riding (upstream) anchor.* She veers on the riding chain, carefully laying out the chain so as to keep it taut and tending ahead as she drops down with the current (wind) to the position for letting go the lee or downstream anchor. When that position is reached the second anchor is let go. She now veers on the lee chain and heaves in on the riding chain, taking care to lay the lee chain out properly until she is riding midway between both anchors with the desired scope of chain to each.

In making a flying moor the ship stands to her berth against the tide, and with considerable headway. When on the proper bearings she lets go the first anchor, *which must always be the lee or downstream anchor.* As she ranges ahead she must veer on the lee chain, keeping this chain taut but being very careful not to drag the anchor. When the proper (mark) shackle on the lee chain is at the bench mark and the chain laid out properly, let go the second (riding or upstream) anchor. The ship should be dead in the water at this point. By veering on the riding chain and heaving in on the lee chain the ship drops back to a point midway between the anchors with the desired scope of chain on each.

Reasons for Making an Ordinary Moor.

1. Safer and more practical than a flying moor when it is necessary to moor in a berth between other vessels.
2. Results in a tauter moor.
3. Better when backing power cannot be relied on.

Reasons for Making a Flying Moor.

1. More expeditious when vessels are mooring in formation.
2. Plotted course is maintained in laying out the anchors.

Putting on the Mooring Swivel.

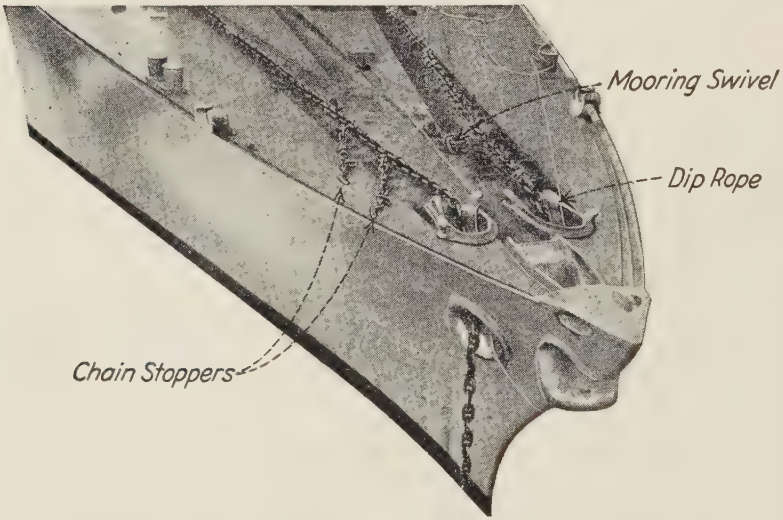
The mooring swivel is used to prevent a foul hawse. Its use requires a taut moor. A slack moor, whether made deliberately or accidentally, defeats the purpose of the mooring swivel because

the swivel will not function. Therefore, when a moor is slack it is better to rely on tending ship, rather than on the mooring swivel, to prevent a foul hawse.

Two methods (the O'Neil and the Eldridge) * have been developed in the U. S. Navy for putting on the mooring swivel. Both require hawse-pipes large enough to allow the free passage of the mooring swivel through them.

Either method can be used with an ordinary moor or a flying moor.

Plate No. 112



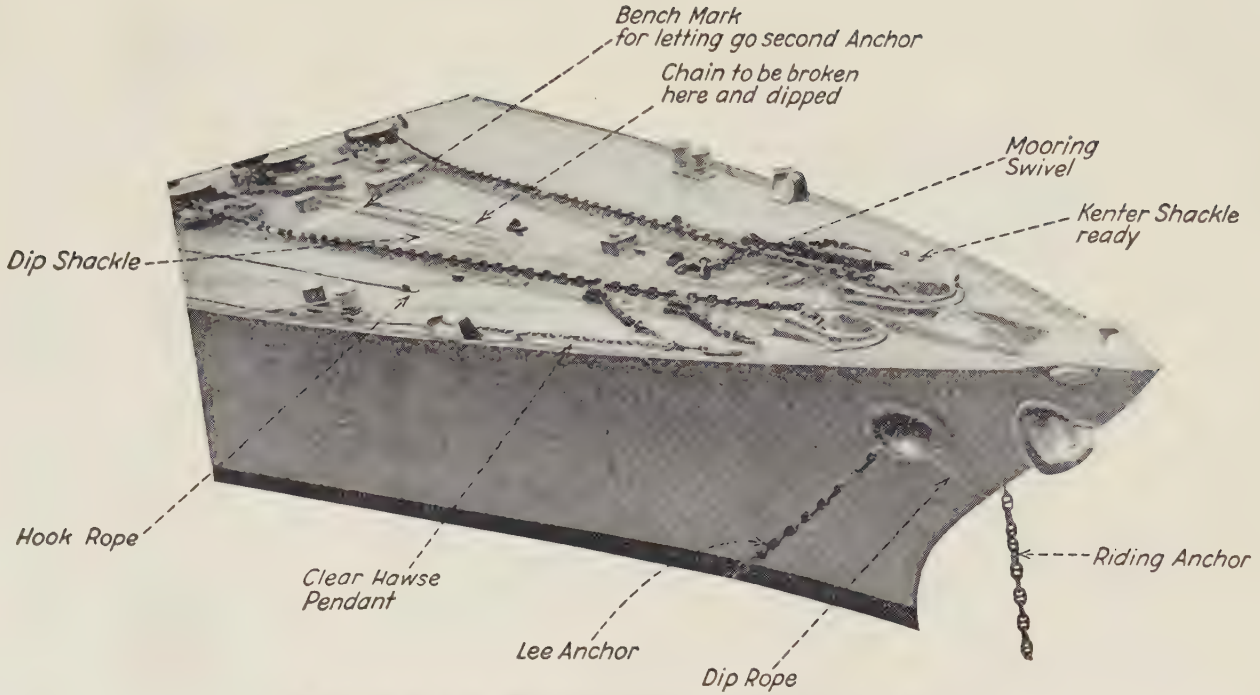
FLYING MOOR, O'NEIL METHOD. (Lee Anchor Down.)

Both chains are leading through their respective hawse pipes. The starboard (lee) anchor is down and the ship is going ahead. The 15 fathom shot is sighted on deck. The port anchor is backed out clear of the hawse pipe and hung to its chain stopper ready for letting go. The dip rope is led from the starboard hawse pipe around the bow and up through the port hawse pipe. The swivel is in view.

The O'Neil Method. (Plates 112, 113, 114 & 115)

Assume the port anchor is going to be used as the riding anchor (upstream or weather); the starboard anchor as the lee anchor. The dip rope is rove out through the port hawse-pipe

* The O'Neil method was worked out by Chief Boatswain J. P. O'Neil, U. S. Navy, in the *U. S. S. Rhode Island*; the Eldridge method by Chief Boatswain M. H. Eldridge, U. S. Navy, in the *U. S. S. Wyoming*.

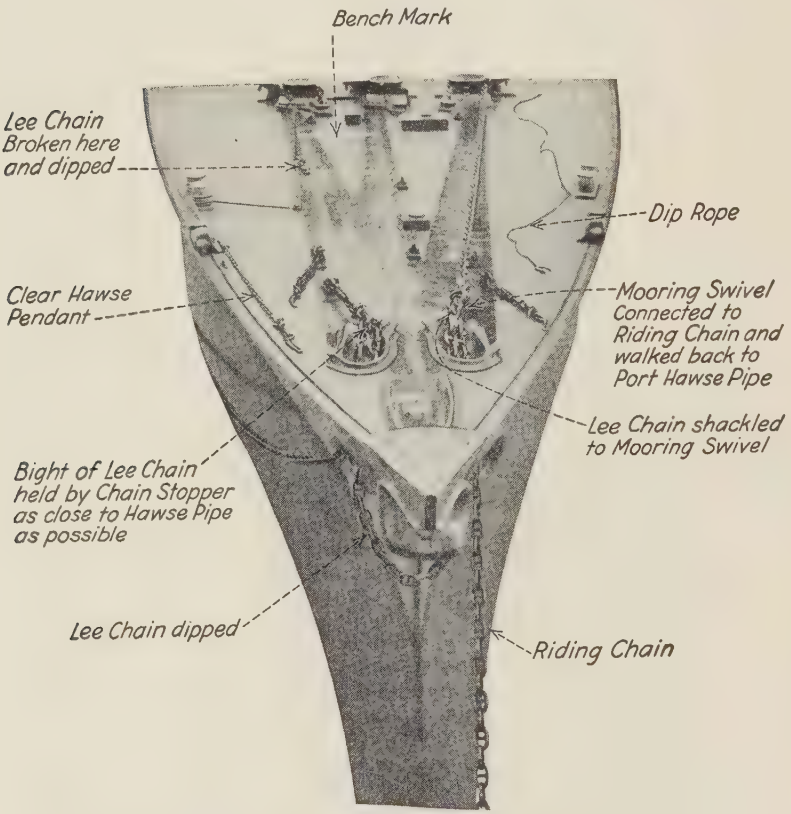


FLYING MOOR, O'NEIL METHOD. (Both Anchors Down.)

Both anchors are down. The starboard (lee) chain is tending aft. The 60 fathom shot is in sight forward of the wildcat. The port (riding) chain is tending forward. The dip rope is dipped and ready for use. The clear hawse pendant is led out on the starboard side ready for use. Also the hook rope is ready on the starboard side. The swivel is in sight. The Kenter shackle is on the port side.

and in the starboard hawse-pipe, hauled taut clear of the chains, and secured. All gear is made ready on deck and placed as nearly as practicable where it is to be used.

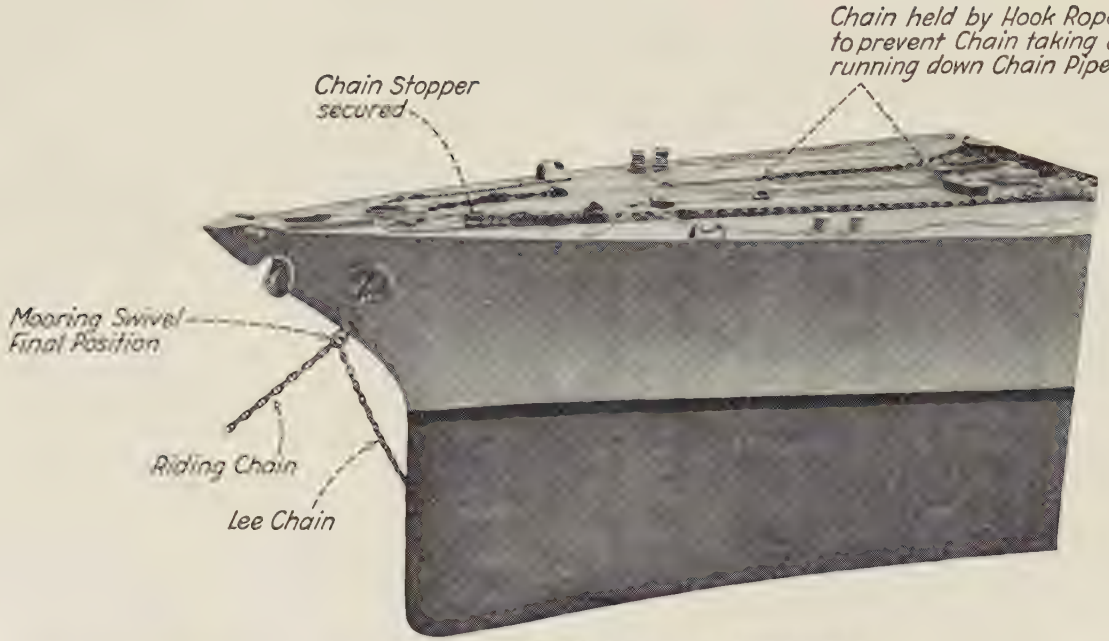
Plate No. 114


Bench Mark
Lee Chain Broken here and dipped
Dip Rope
Clear Hawse Pendant
Mooring Swivel Connected to Riding Chain and walked back to Port Hawse Pipe
Lee Chain shackled to Mooring Swivel
Bight of Lee Chain held by Chain Stopper as close to Hawse Pipe as possible
Lee Chain dipped
Riding Chain

O'NEIL METHOD. (Mooring Swivel on Both Chains.)

Both anchors are down. The port (riding) chain is tending forward and the starboard (lee) chain is tending aft. A bight is hung from a chain stopper, around the bow and is led through the port hawse pipe. Both chains are bent to the swivel and also to the port chain which is on deck. The inboard end of the starboard chain is secured to the hook rope and is backed down into chain locker. The clear hawse pendant is in view on the starboard side of the deck. The dip rope is in view on the port side of the deck.

The drift on the port (riding) chain will be the distance from a point just abaft of the inboard chain stopper (clear hawse or preventer) used to hold the port (riding) chain when that chain


Chain held by Hook Rope and Lashing to prevent Chain taking charge and running down Chain Pipe to Locker.
Chain Stopper secured
Mooring Swivel Final Position
Riding Chain
Lee Chain

O'NEIL METHOD. (Moor Completed.)

Ship is moored with 45 fathoms of chain on both anchors. The swivel has been veered outside of the port hawse pipe. The chain stopper on the bight of the starboard chain has been tripped. The ship is riding to the port anchor and the port chain. The starboard anchor is still the lee anchor. The starboard chain is on deck secured to the hook eye and has been backed down into the chain locker. The clear hawse pendant is in view on the starboard side of the deck and the dip rope on the port side of the deck.

is broken to insert the mooring swivel, to the final position of the mooring swivel outside the hawse-pipe. The drift on the starboard (lee) chain is the length of chain from the outboard lip of the starboard (lee) hawse-pipe, to the inboard chain stopper on that chain plus the distance from this stopper out through the starboard (lee) hawse-pipe and up through port hawse-pipe to the deck at port hawse-pipe. On ships where the drift on the lee chain is excessive it can be reduced considerably by holding the lee chain at the water's edge with a clear-hawse pendant and preventer while the lee chain is broken, dipped and shackled to the mooring swivel. If this is done, the drift on the lee chain will be reduced to the distance from the deck at the hawse-pipe of the riding chain to the clear-hawse pendant on the lee chain as measured along a fairly slack line. The use of the clear-hawse pendant and preventer secured to the lee chain at the water's edge will result in a tauter moor. Once the drift has been measured the bench mark can be established.

After both anchors are let go (ordinary or flying moor) the ship is riding to the port anchor with a length of chain on each anchor equal to the desired scope on each chain minus its drift. The port (riding) chain is held by two chain stoppers or a chain stopper and preventer and the mooring swivel inserted. As soon as this is completed, the strain on the port (riding) chain is taken by the wildcat, the chain stoppers (or clear-hawse pendant) tripped and the mooring swivel walked back to the hawse-pipe.

While the port (riding) chain was being connected to the mooring swivel, the starboard (lee) chain was stoppered abaft its hawse-pipe; and disconnected far enough aft so that the inboard end of the chain attached to the anchor could be dipped by the dip rope out through the starboard (lee) hawse-pipe, around the bow, into the port (riding) hawse-pipe and shackled to the mooring swivel.

After the starboard (lee) chain is shackled to the mooring swivel the stopper holding the starboard (lee) chain is tripped and the bight of the lee chain in the lee hawse-pipe allowed to run out. The mooring swivel is then walked back to its position outside the hawse-pipe.

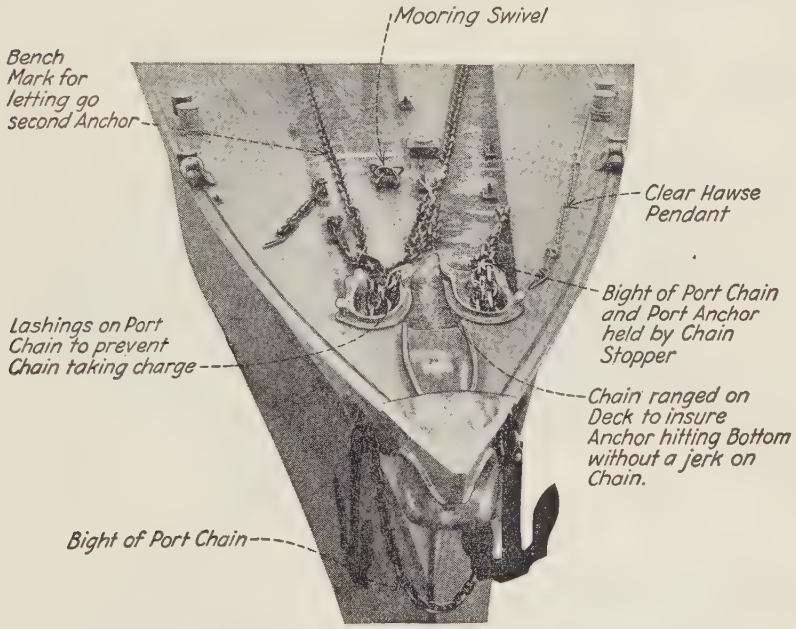
The ship is now riding to the port anchor from the port hawse-pipe. The starboard anchor is the lee anchor.

The Eldridge Method. (Plates **116, 117, 118, 119 & 120.**)

Assume, as was done in the O'Neil method, that the ship is going to moor so that the port and starboard anchors will be riding and lee anchors respectively.

The port (riding) anchor is lowered clear of its hawse-pipe and hung by two chain stoppers. The starboard (lee) anchor is

Plate No. 116


Mooring Swivel
Bench Mark for letting go second Anchor
Clear Hawse Pendant
Bight of Port Chain and Port Anchor held by Chain Stopper
Lashings on Port Chain to prevent Chain taking charge
Chain ranged on Deck to insure Anchor hitting Bottom without a jerk on Chain.
Bight of Port Chain

ELDRIDGE METHOD. (Ready to Let Go First Anchor.)

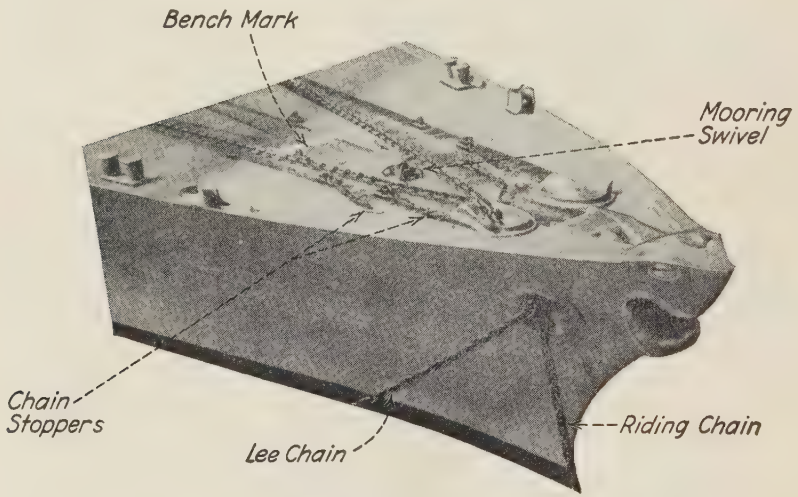
Both anchors are backed out clear of hawse pipes and hanging to chain stoppers. Both chains are leading through the starboard hawse pipe. After the port chain has been dipped and brought around bow, the bight of the port chain is lashed to the lip of the starboard hawse pipe and also to a deck pad-eye. The swivel is in view, also the clear hawse pendant can be seen led out in case it is needed.

lowered clear of its hawse-pipe and hung by one chain stopper. Reeve the dip rope (dip shackle end) down and out through port hawse-pipe around bow and up through starboard hawse-pipe, shackle it to port chain inboard of where chain is to be disconnected. Lead tail (hauling part) of dip rope to the winch or capstan.

Rouse out some slack on port chain and inboard of the connecting shackle at the bending shot, pass a strong lashing to avoid the danger of the chain taking charge and running down the chain pipe to chain locker and injuring personnel. Such a precaution should always be taken when the chain is broken to disconnect, to insert or take out the mooring swivel, or to connect up the chain.

Unshackle the port (riding) chain at the bending shot. Lead the port chain outboard of port riding bitts by the chain plate in

Plate No. 117



Both anchors are down and both chains leading through the starboard hawse pipe. The starboard (lee) chain is hove in to the 30 fathom shot at the bench-mark on deck, the port (riding) chain is being veered out and the 30 fathom shot is nearing the benchmark. The swivel is in view ready to be put on.

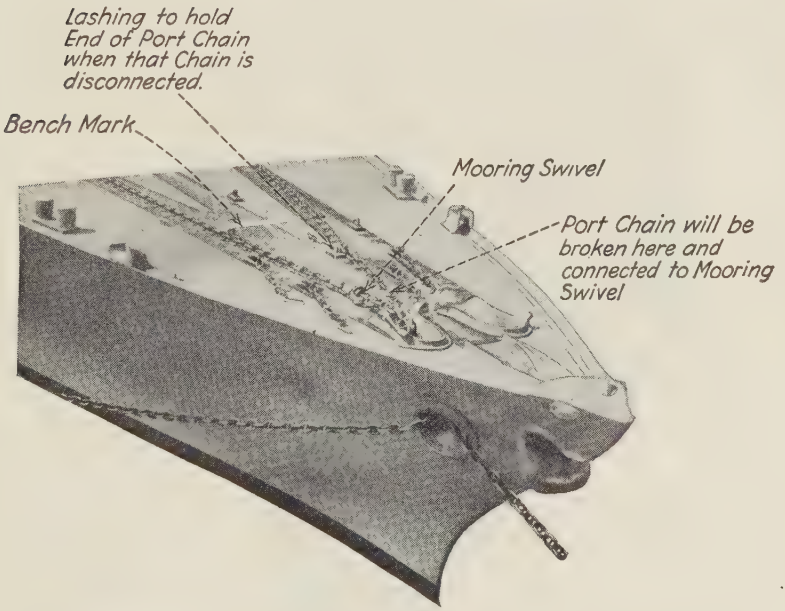
order to give it a good lead to the starboard hawse-pipe. Heave in on dip rope and haul the end of the port chain out through the starboard hawse-pipe around the bow and into the port hawse-pipe, then shackle it to the bending shot on the port anchor. Ease bight of port chain out until stoppers have strain, disconnect and clear away the dip rope.

Another precaution to be observed here is to make sure that the bight of chain stoppered at the port (riding) hawse-pipe is as close to the hawse-pipe as practicable to avoid its whipping forward when the port (riding) anchor is let go and fracturing

a link by striking against the hawse-pipe. This is done by tripping the after one of the two chain stoppers on the port chain and walking back the bight to the hawse-pipe.

If the amount of chain on the bight is not enough, range a sufficient length of port chain on deck, stoppering the bights, to

Plate No. 118


Lashing to hold End of Port Chain when that Chain is disconnected.
Bench Mark
Mooring Swivel
Port Chain will be broken here and connected to Mooring Swivel

ELDRIDGE METHOD. (Mooring Swivel Inserted in Lee Chain.)

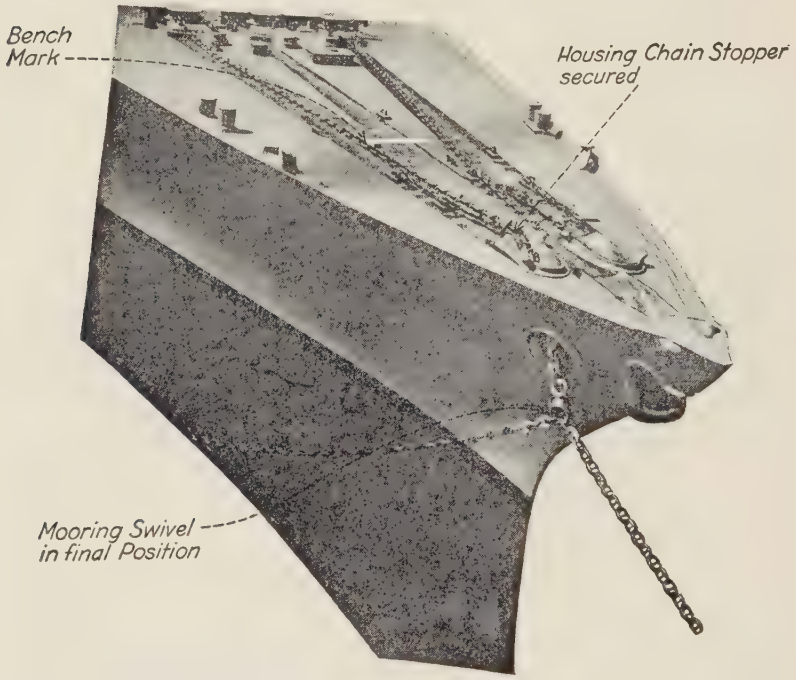
Both anchors are down. The swivel is bent on both chains and also to the starboard chain on deck. The starboard lee chain is tending aft and the port (riding) chain is tending forward. The swivel is ready to be veered to the outside of the starboard hawse pipe.

insure the port (riding) anchor reaching bottom without a jerk. All is now in readiness for the moor.

Either an ordinary moor or a flying moor can be made. If an ordinary moor is made, the anchor on the bight (the riding anchor) must be the first anchor let go. If a flying moor is made, the anchor on the bight (the riding anchor) is the second anchor let go. The anchor on the bight must always be the riding anchor to avoid a cross in the hawse.

After both anchors have been let go and the ship is riding to the port (riding) anchor the mooring swivel is ready to be put on the chain. There will be a length of chain to each anchor equal to the ultimate scope minus the drift. The starboard (lee) chain is held

Plate No. 119



ELDRIDGE METHOD. (Moor Completed.)

The ship is moored at thirty fathoms of chain on both anchors, and the swivel is veered to the outside of the starboard hawse pipe. All chain stoppers are secured to the starboard chain on deck. The ship is riding to the port anchor.

by a chain stopper, broken at the proper shackle, and the mooring swivel inserted. As soon as this is completed the strain on the chain is taken by the wildcat, the chain stoppers tripped and the mooring swivel walked back to the hawse-pipe. The port chain is now held by two chain stoppers (clear-hawse pendant), broken, and shackled to the mooring swivel. Trip the chain stoppers

(clear-hawse pendants) and walk back the mooring swivel to its final position outside the hawse-pipe. The moor is completed.

The ship is riding to the port anchor from the starboard hawse-pipe.

Since both chains lead out through the same hawse (lee) pipe the drift on the lee chain will be the distance from the final position of the mooring swivel outside the hawse-pipe to the point just abaft the stopper that holds the lee chain when it is broken. After the mooring swivel has been connected to the chain it is walked back to the hawse-pipe. Therefore the drift on the riding chain is measured from this position of the mooring swivel to its final position outside.

STEPS IN MOORING

ORDINARY MOOR—(ELDRIDGE METHOD)

NOTE: Steps No. 4 to No. 11 inclusive apply to all methods of ordinary moor where the ship's hawse-pipe is large enough to take two chains.

1. Lower riding anchor and hang by two chain stoppers. Lower lee anchor and hang by one chain stopper.
2. Rouse out on deck some slack on riding chain and lash it so that slack chain will not run back into chain locker.
3. Unshackle riding chain at bending shot and lead it (not the bending shot) out the other hawse pipe, around the bow and back in through own hawse pipe and then shackle it again to bending shot on own anchor. Both chains now lead through same hawse pipe, but are attached to their own anchors.
4. Ship stands against current (wind) at slow speed to the proper position and lets go the riding (up stream) anchor. (This is the anchor on the bight to avoid a cross in the hawse.)
5. Veer on riding chain, keeping it taut, as ship drops down with the current (wind) to the position for letting go the lee (down stream) anchor.
6. Let go lee (down stream) anchor.
7. Veer on lee (down stream) chain and heaves in on riding (up stream) chain until ship is riding midway between both anchors with the desired scope of chain to each.
8. Hold lee (down stream) chain by a chain stopper, break chain at proper shackle, and insert mooring swivel.
9. Take strain on lee chain by wildcat, trip chain stoppers, and walk mooring swivel back to hawse pipe.
10. Riding (up stream) chain held by two chain stoppers, broken and shackled to the mooring swivel.
11. Trip chain stoppers and walk back the mooring swivel to its final position outside the hawse pipe.

FLYING MOOR—(ELDRIDGE METHOD)

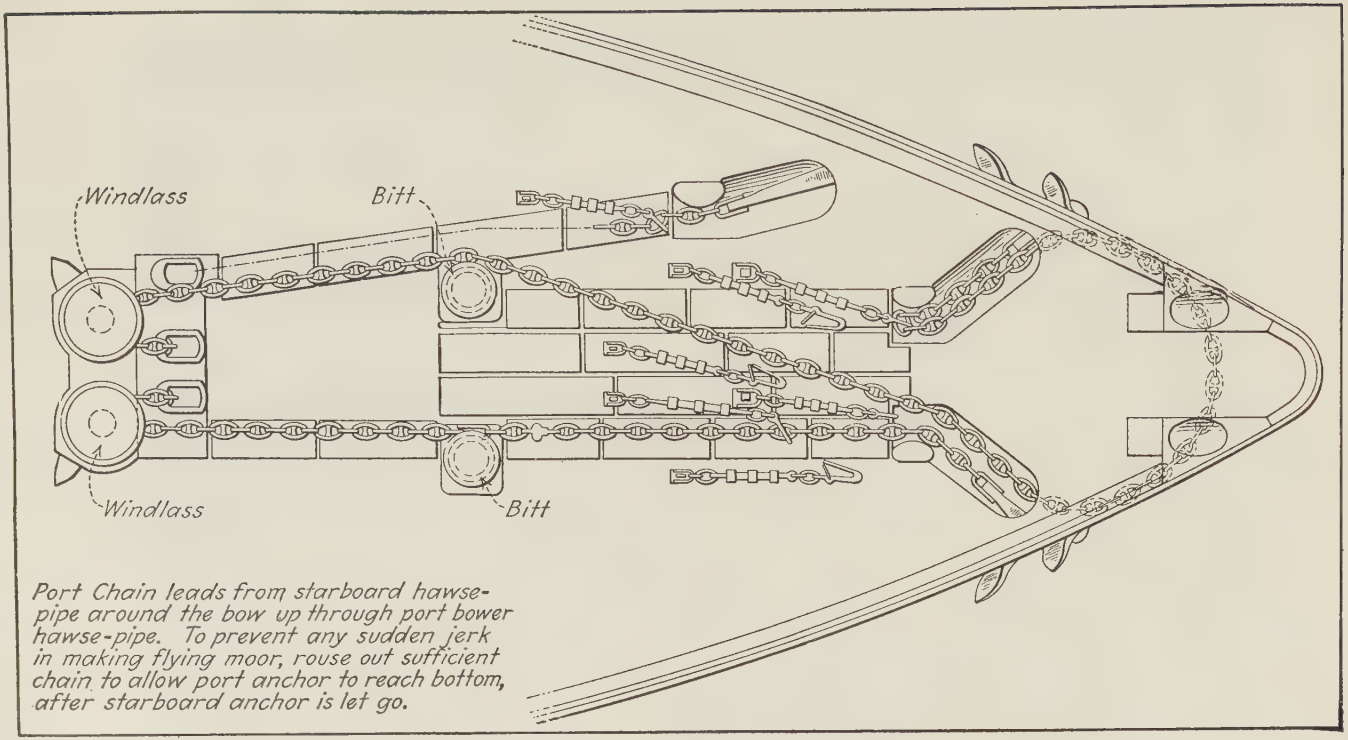
1. Same as for ordinary moor (Eldridge Method).
2. Same.
3. Same.
4. Ship stands against current (wind) at slow speed to proper position and lets go lee (down stream) anchor. This is not the anchor on the bight.
5. Ship ranges ahead, veers on lee (down stream) chain, keeping it taut but being careful not to drag anchor.
6. Let go riding (up stream) anchor (the anchor on the bight). Ship should be dead in the water at this point.
7. Veer on riding (up stream) chain and heave in on lee (down stream) chain until ship is riding midway between both anchors with the desired scope of chain to each.
8. to 11. Same as for ordinary moor.

Comparison of the Two Methods.

In deep water, the Eldridge method will require a great length of riding chain ranged on deck. This constitutes a danger to the personnel on the forecastle and to the chain itself due to the liability of a bight whipping as the riding chain runs out. The O'Neil method requires no extra chain ranged on deck and is therefore the safer method to use when mooring in deep water. The O'Neil method will be the safer method when mooring with inexperienced personnel. On the other hand, the Eldridge method is more expeditious and will always result in a taut moor whereas the O'Neil method results in a comparatively slack moor because of the excessive drift in the lee chain.

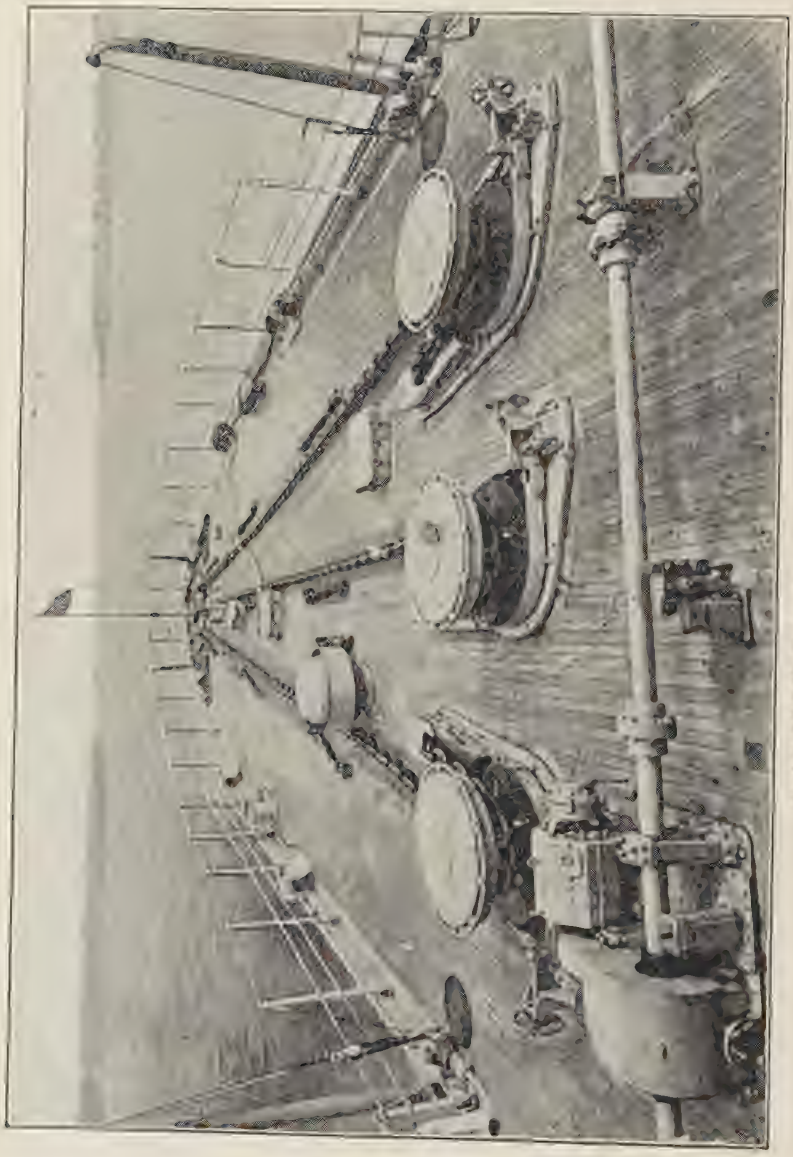
Both Methods—To Unmoor.

Heave in on the chain that is connected to the mooring swivel and bring the mooring swivel on deck. Stopper the lee chain outboard of the mooring swivel. Lead the outboard end of the unused chain out through its own hawse-pipe, dip it around the bow and into the riding hawse-pipe with the end at the mooring swivel. Disconnect the lee chain from the mooring swivel and shackle it to the chain that was dipped. Trip the stopper on the lee chain and let the bight go out the hawse-pipe. Secure the riding chain with two chain stoppers forward of the mooring swivel. Rouse out some slack, disconnect the mooring swivel,

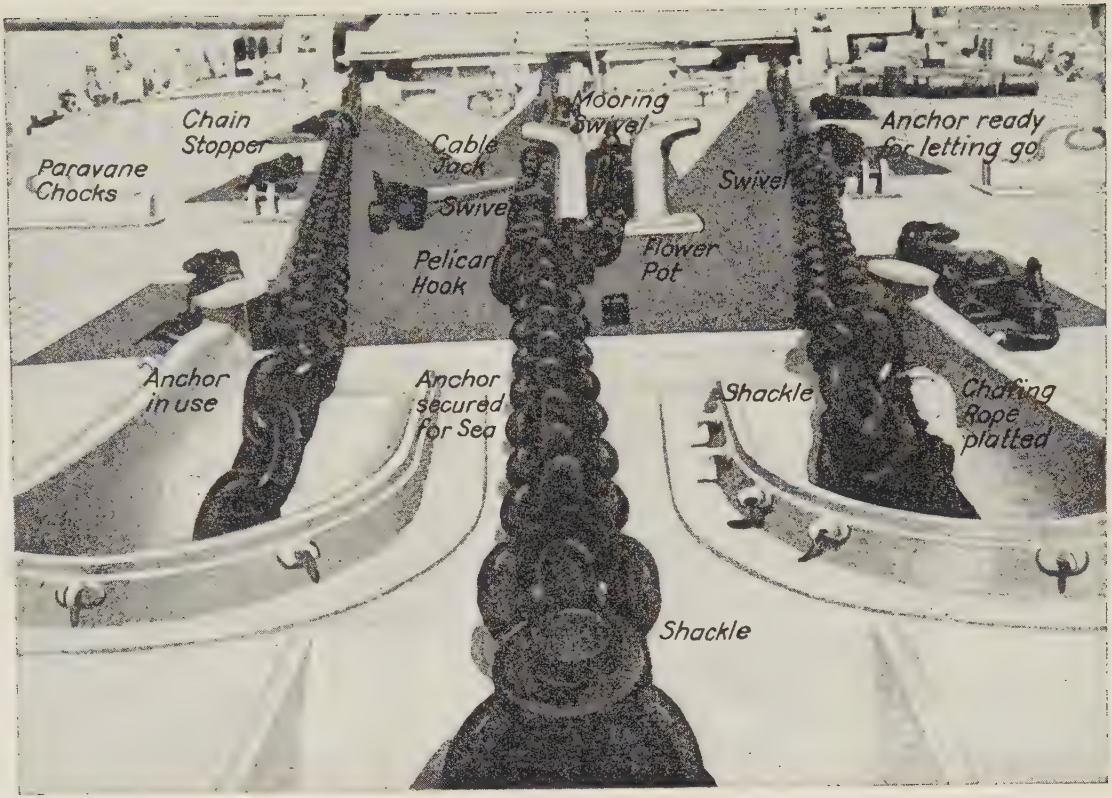


Port Chain leads from starboard hawse-pipe around the bow up through port bower hawse-pipe. To prevent any sudden jerk in making flying moor, rouse out sufficient chain to allow port anchor to reach bottom, after starboard anchor is let go.

PREPARATIONS FOR MOORING. ELDRIDGE METHOD OF PUTTING ON SWIVEL.



FORECASTLE U. S. S. MISSISSIPPI.



FORECASTLE OF THE U. S. S. WEST VIRGINIA.

and shackle both parts of the riding chain together. Take the mooring swivel out of the way. Heave in on the riding chain until the wildcat takes the strain, then trip the two chain stoppers. Make ready and veer on the riding chain and heave in on the lee chain until the lee anchor is aweigh.

O'Neil Method—To Unmoor

If, at unmooring, the ship is riding to the same (opposite tide for Eldridge) tide as when she moored, each anchor will be returned to its original chain makeup. Should the ship unmoor on the opposite (same tide for Eldridge Method) tide to that on which she moored, the port anchor will be returned to the starboard side and the starboard anchor to the port side. As both anchor chains are identical such a condition will be of little concern. However, a record of the shift of anchors and shots of chain should be made in the record book.

If, for some reason, it is desirable to return the anchors to their original sides when unmooring on the opposite (same tide for Eldridge Method) tide, lead that chain whose free end is on deck out through its own hawse-pipe and shackle it to the mooring swivel. Heave in on the chain just shackled to the mooring swivel and veer on the other chain. This will bring the mooring swivel, the lee chain and its own part on deck. Then proceed as before in taking off the mooring swivel.

Tending Ship.

When the swivel is not used, it is very important to tend ship; that is, to watch the swinging at each turn of the tide, note the direction in which the stern swings, always recording this in the log, and, taking advantage of any conditions which may be helpful to make the ship swing to that side which will keep the hawse clear, or clear it if it has already fouled.

It is well to give some attention to tending ship even when the swivel is in use. The purpose of the swivel is to prevent the hawse from fouling, but unfortunately it does not always work. It is especially likely to fail if the moor is slack, and in this case the chains may foul so far below the surface of the water that it may not be known that they are foul until the ship starts to unmoor. It is not unusual to find anchor cables very badly

fouled when every confidence is felt that they are perfectly clear. *It is very important to watch the swivel while the ship is swinging and to note whether or not it functions.* If it does not, it may be practicable to heave it around by a purchase hooked to that part of the chain which should be lifted. To assist in keeping track of the working of the chains, it is a good plan to paint a link of each chain just outside the swivel, using red for the port and white for the starboard cable.

To Clear Hawse.

This should be done if possible at slack water, preferably just before the ship has finished swinging and before the new tide begins to run strongly. (Plates **111, 123, 124.**)

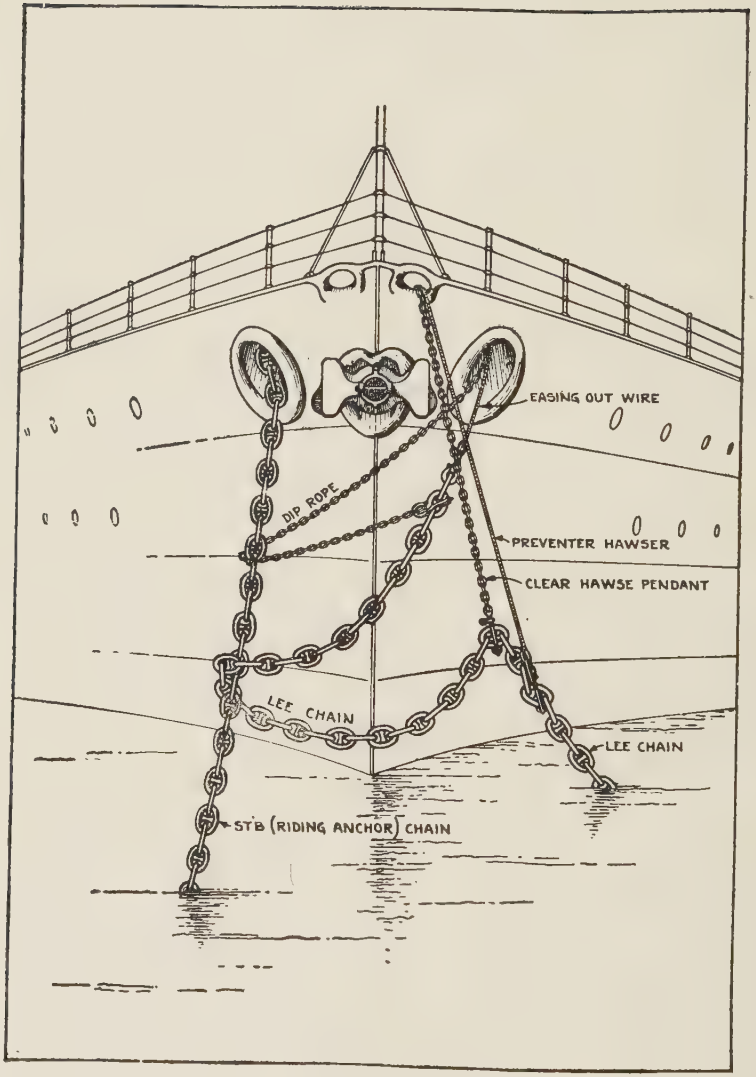
If the moor is slack, it is possible that the hawse will look clear when it is in fact badly fouled. If there is any reason for doubt as to the cables being clear, it is a good plan to underrun the riding cable for some distance with the bight of a boat anchor chain.

If proper entry has been made in the log as to how the ship has swung this will be of great value in clearing the foul hawse. By far the easiest way to clear a foul hawse, if time permits, is to use the rudder to insure the ship swinging properly on each change of tide to clear the hawse by her swing.

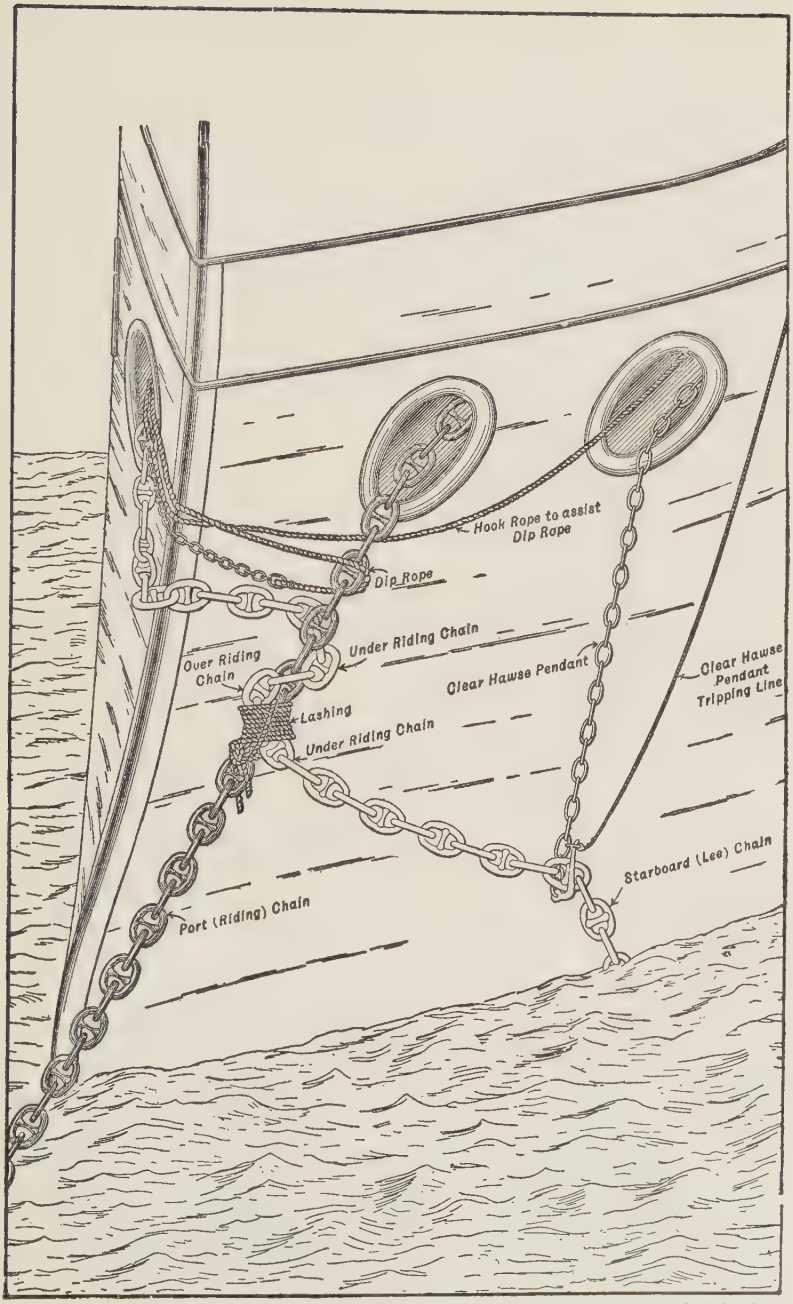
When the turns in the cable are below the water's edge they must be brought above by heaving in the riding cable. If they are inclined to slip down they must be lashed; it is best that they be lashed in all cases as this reduces the chance of accident to the men working on them.

After the turns are securely lashed, heaving in on the riding chain and veering on the lee chain will bring the turns up on one side of the bow. The clear-hawse pendant is passed through the hawse-pipe, or chock, and secured to the lee chain below the turns (Plates **123, 124**), after which it is hauled taut and secured on deck. The preventer hawser is passed, bent to the cable, hauled taut and secured.

Secure the lee chain with a chain stopper so that the shackle to be broken is inboard of the chain stopper. Lash inboard end of lee chain to prevent danger of it taking charge and running back down the chain pipe to the chain locker when chain is dis-



CLEARING HAWSE.



Note:—The starboard anchor lies to starboard of the ship.

CLEARING HAWSE.

connected. Unshackle the chain. Meanwhile the dip rope has been passed out of the hawse-pipe alongside the lee chain; taken around the riding cable in a direction opposite that of the turns to be taken out, and brought back inside, where it is secured to the end link of the chain to be dipped. After the dip rope is made fast and hauled taut, come up on the preventer lashing on inboard end of lee chain. It will be well to use an easing-out line to control the chain while hauling it out. If the lead of the dip rope is unfavorable for hauling out it may be necessary to lead a hauling-out line through the riding hawse and back in through the lee hawse to be bent to the lee chain to start it out. Chain hooks, hook-ropes and tackles may be necessary for lightening a heavy chain forward.

When the turns have been cleared the lee chain is brought back in its own hawse-pipe by the dip rope and secured by a stopper; all lines cast loose from the end link, the parts of the lee cable shackled together and the slack chain on deck hove in.

With light chain a foul hawse is often very easily cleared from a boat under the bow, the shackle being veered out to the boat and there unshackled, the turns cleared by dipping the chain by hand. The turns should be lashed and the weight of the lee chain held by lines led from the ship's bow.

A cross in the hawse cannot be cleared by dipping the chain, because the chains lead off on the wrong sides, the starboard anchor being on the port hand and the port anchor on the starboard hand. (Figs. 3 and 4, Plate **125**). The chains may be unshackled and shifted (the former starboard chain becoming the port chain and the port becoming the starboard), provided this is not impracticable by reason of differences in anchor stowage, type of chain, or other practical reasons. If it becomes necessary to weigh when there is a cross in the hawse, the anchor belonging to the cable underneath must be weighed first, as the upper one, if weighed, would foul the other chain.

When heavy chain has become fouled it is a strenuous task even under favorable circumstances to clear the hawse. Each case presents a problem that requires thought and ingenuity to obtain success in the shortest time. If time permits the rudder can be used to make sure that the stern swings the proper direction on

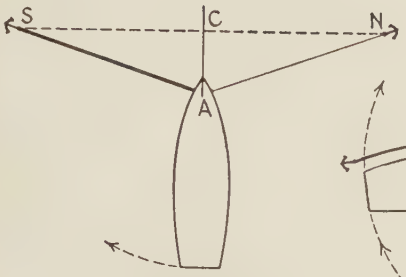


FIG. 1.
OPEN HAWSE

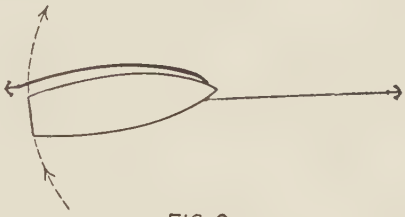


FIG. 2.
OPEN HAWSE

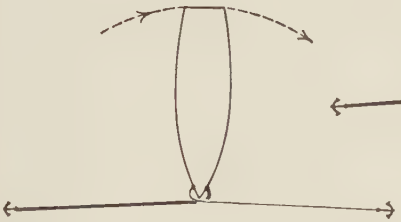


FIG. 3.
A CROSS IN THE HAWSE

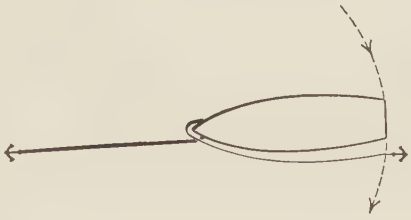


FIG. 4.
A CROSS IN THE HAWSE

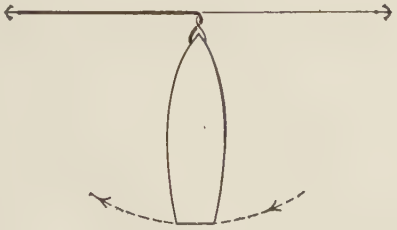


FIG. 5.
AN ELBOW

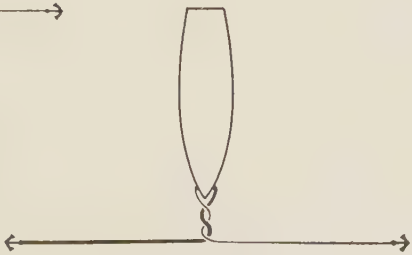


FIG. 6.
A ROUND TURN

SHIP MOORED.

subsequent changes of tide to clear the hawse. If time is a factor and the hawse badly fouled it will be much the quicker to obtain the services of a crane barge or large tug to lie under the bow and clear the chain.

CHAPTER XI.

CARRYING OUT ANCHORS.

The types of anchors carried by men-of-war of recent design are patent "bower" anchors, stockless and double fluked, housed in the hawse-pipes; "stream" or "stern" anchors of from one-fourth to one-third the weight of the bowers; and "kedge" anchors weighing much less. For example: a battleship equipped with three 20,000-pound bower anchors, carries one 5,000-pound stream anchor, and one 500-pound kedge anchor; while a ten thousand ton cruiser is equipped with two 13,000-pound bower anchors, and one 400-pound kedge anchor.

An anchor which stows in the hawse-pipe is not fitted with a balancing band and must be handled by a strap. The strap may be placed at the balancing point, or it may be passed around the crown, in which case it allows the anchor to hang "ring-heavy." The latter arrangement has some advantages, as will be explained hereafter.

Neither the stream nor the kedge anchor is too heavy to be carried out by a single boat, and the problem of handling them presents no great difficulty, provided the method to be used has been thought out beforehand and all the gear prepared. It is quite a different proposition to deal with a bower anchor weighing from eleven to thirty thousand pounds, and stowed without any thought of the possible necessity of carrying it out by boats. Several boat methods suitable for bower anchors will be described, but when available a tug and lighter are more practicable in handling an extremely heavy anchor.

There is a definite relationship between the size of a ship and the size anchors and boats with which she is equipped. The following four methods of carrying out anchors are as general as possible and must be modified or altered to meet the requirements of the particular situation for which they are used. The first method concerns light anchors, the other three heavier ones.

First Method—Plate **126.**

The simplest way to carry out an anchor is to hang it from the bow or stern of a boat, but this utilizes only a part of the floating power of the boat and is not practicable with a very heavy anchor. The weight that can be carried by this method may be greatly increased by adding weight near the opposite end, thus counterbalancing the weight of the anchor and bringing the boat to a proper trim. In this way the boat may be made to carry approximately one-half of its total floating capacity.

A convenient way of hanging the anchor and letting it go is illustrated in Plate **126**, where one end of the wire strap is shackled to a hoisting pad, while an eye in the other end engages a pelican hook secured to a hoisting pad in the keel. The pelican hook should be fitted with a lanyard for letting go, and the lead from hoisting pad to pelican hook must be as short as possible to prevent a dangerous whip when the pelican hook is released. The securing points for the strap and hook may be hoisting pads, cleats, samson post, or any convenient point depending on the size anchor and boat to be used. When the boat is to use its own motive power the anchor should be carried out over the bow.

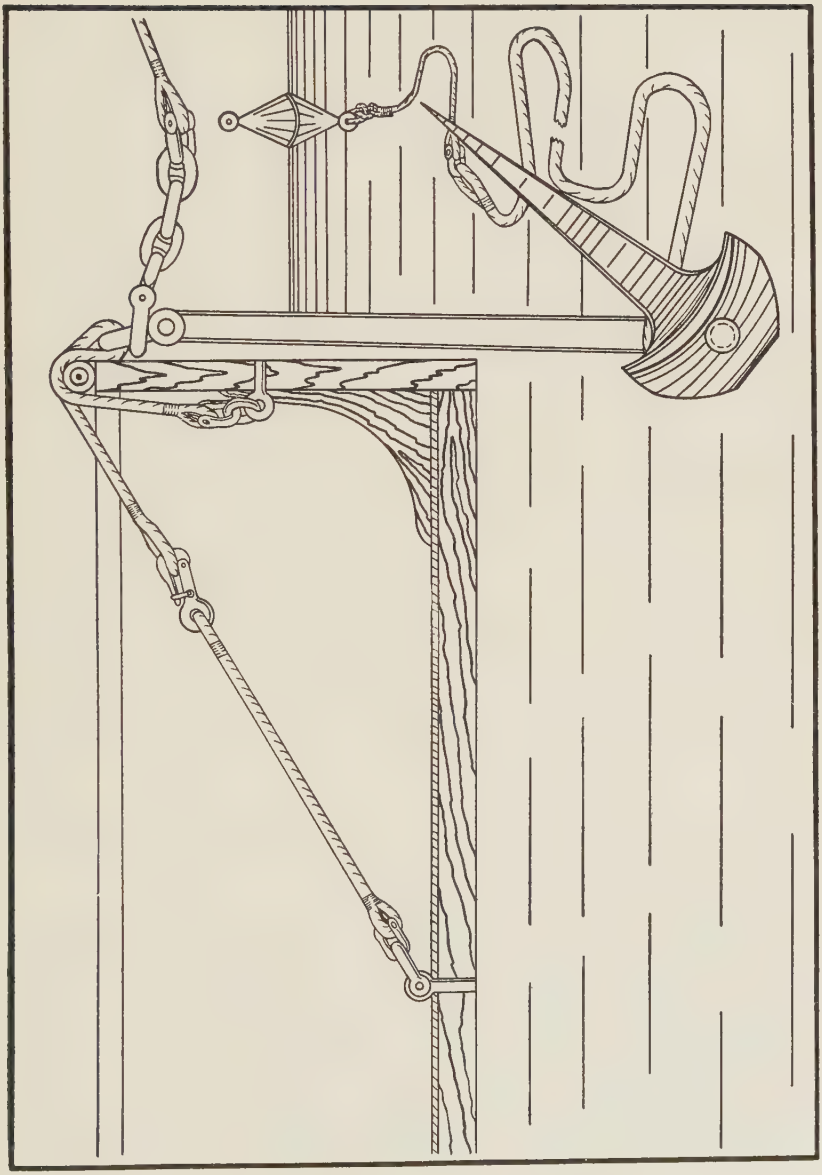
In all cases where an eye is to engage a pelican hook, the eye must be made large enough to allow the tongue of the hook to run through it freely when released. The eye is better without a thimble.

For weighing, a "weighing-line," usually of wire, is bent to the crown of the anchor, and fitted with a "buoy-rope" and buoy.

The "hauling line," of manila or wire, is bent to the ring of the anchor and leads to the ship.

Running the Line. With a light anchor it may be assumed that a manila hawser will be used for a hauling line. In this case the end of the line is bent to the ring and the line is payed out from the ship as the boat pulls away; a considerable length of the line, however, being coiled in the boat ready to be thrown over as the point is approached where the anchor is to be dropped. The throwing over of this part of the line at the last gives freedom of control to the boat at a point where the long bight of line, dragging astern, would otherwise be embarrassing.

In some cases, with a manila line, it is better to coil the whole length of the line in the boat and carry it out with the anchor.



CARRYING OUT ANCHOR. FIRST METHOD

The line is payed out as the boat returns to the ship after the anchor is let go. This is especially convenient when the anchor has to be carried out against or across a strong wind or tide. In this case it is a good plan to let the boat hold on to the anchor after dropping it and to send out another boat from the ship with the end of a 3- or 4-inch manila line, the other end of which is taken to the winch. The first boat can then be hauled back to the ship by the small line, paying out the hawser from the anchor as she comes.

When any part of the line is carried in the boat, enough must be thrown over before letting go, to make it certain that the anchor will reach bottom with plenty of slack line to spare.

Where a wire line is to be run, it is always better to send the end away with the anchor, and pay out the line from the ship, although here, as in all other cases, a few fathoms should be coiled in the boat. The difficulty in dealing with a large coil of wire in the boat lies in its stiffness, its tendency to kink, and its disposition to "take charge" if the stops by which it is being towed should part. A convenient way to secure the line to the boat when paying out from the ship is shown in Fig. 2, Plate **128**. The stopper used may be either a single line or a span with one part leading to each quarter of the boat.

It is sometimes practicable to take a wire line on a reel, the reel being lashed very securely in place on a temporary platform in the boat. The line can then be payed out directly from the reel.

If a long scope of line is to be run out, the weight of the bight should be taken by one or more boats, holding it by slip-ropes from the bow and stern.

In all cases of carrying out an anchor, except when dealing with a light kedge, it is well to tow the boat from which the anchor is hung. The reason for this is that a boat carrying an anchor hung over the stern or under the bottom is not free to maneuver and will obey her rudder sluggishly or not at all. An alternate plan is to lay out a kedge some distance beyond the point where the anchor is to be planted and to haul the boat out by a manila line bent to the ring of the kedge.

Second Method—Plate **127**.

This is a very convenient method provided preparations have been made for it in advance.

A "spreader" is required to relieve the crushing strain on the sides of the boat. This may rest on blocking, as in Plate **127**, or if the anchor is not too heavy, on the gunwales of the boat. It is well to lash the spreader to a thwart and also to seize the "belly-strap" temporarily to the spreader. The seizings are cut before letting go.

The anchor may be hung by the balancing band, if one is fitted, or by a strap around the shank and crown as shown in the plate. With this strap the anchor will hang more or less "ring-heavy," and the strap is available for breaking out and weighing the anchor, crown first.

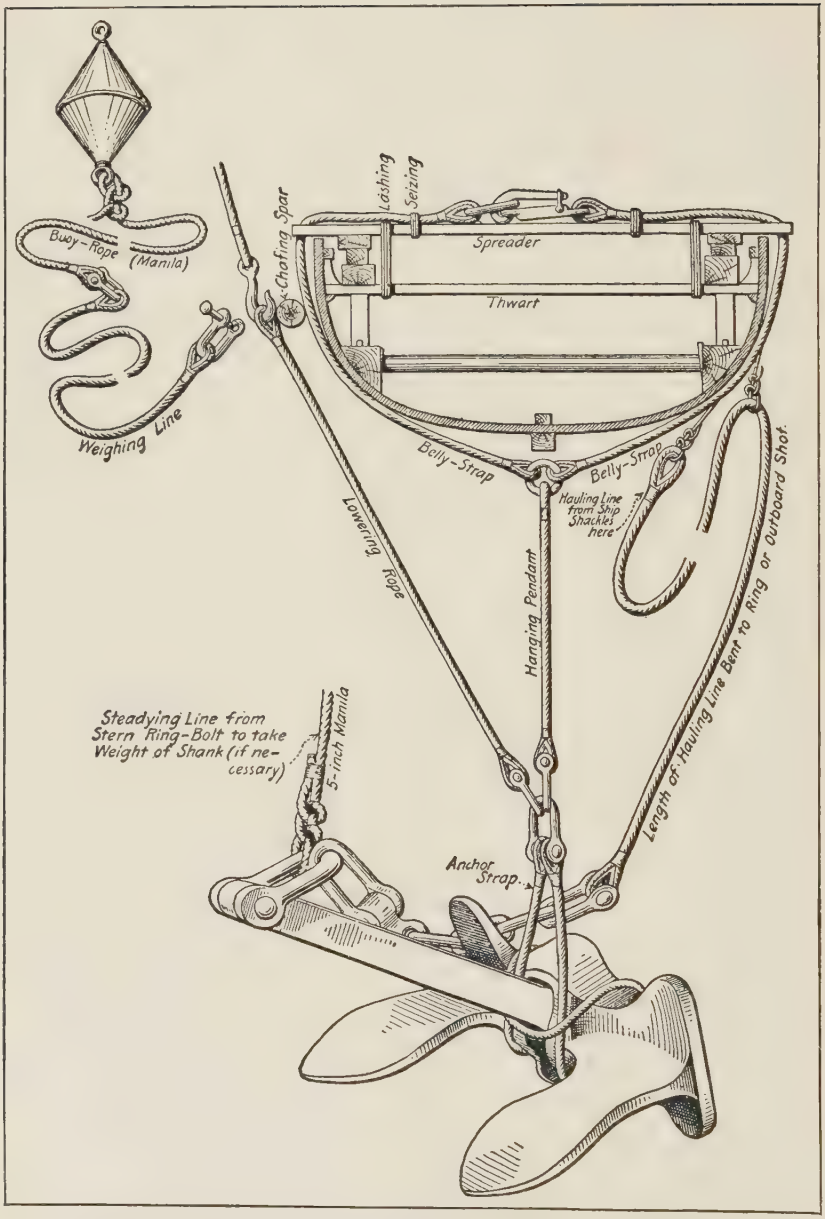
The hanging-pendant must be long enough to reach from the ring under the keel to the water's edge, where it is shackled to the anchor strap.

The use of the "lowering rope" admits of unhooking after the anchor is lowered into place under the boat.

The weighing-line is shackled to the end of the lowering-rope, and a buoy rope and buoy bent to the weighing-line.

Where the hanging-pendant from the boat leads off at an angle at the time when it begins to take the weight of the anchor, a strong pull will be exerted which will drag the boat toward the anchor. This is not necessarily a matter of great importance, but is a factor with which to reckon. As its tendency is to draw the boat against the lowering rope, it is well to use a "chafing-spar" alongside to protect the bilge, as shown in the plate.

The hauling-line leads from the ring of the anchor to the ship. It is usually bent to the ring and run out with the anchor as has been described in connection with the First Method. With a heavy anchor it is better to use a "hauling-pendant" on the ring of the anchor, long enough to reach well above water after the anchor is on the bottom. The boat holds on by this pendant, and the hauling-line is sent out by another boat and shackled on. Much trouble is saved by thus carrying out the anchor and the line separately. Ten fathoms is a convenient length for the hauling-pendant, and should be long enough for all ordinary demands.



CARRYING OUT AN ANCHOR—SECOND METHOD.

If it is preferred not to let the anchor hang "ring-down," a manila line may be bent to the ring and brought in over the bow or stern of the boat, holding the ring well up under the keel. The hauling-line, or hauling-pendant may be utilized for this purpose.

If the anchor has a balancing band, it may be handled altogether by this; in which case the weighing-line must be bent independently to the crown to admit of breaking out the anchor, crown first. In this case the lowering-rope and hanging-pendant are shackled to the balancing band.

In handling a bower anchor it is necessary to provide for unbending the chain. It is convenient to disconnect at the 5-fathom shackle, and to bend the hauling-line to the end of the length of chain which remains on the anchor instead of directly to the ring.

The shackle may be veered outside and handled there, or a wire hawser may be bent to the cable inside just forward of the shackle, the wire is then taken to the winch and hauled taut, after which the cable is unshackled and the anchor with the outboard shot veered away by the line.

In handling the chain outside, the weight is taken by slip-ropes and tackles from the forecastle.

It is often very difficult to handle a boat under the ship's bow; as for example, when there is a heavy sea running, or a strong current. Under such circumstances one or more kedge anchors may be laid out and the boat controlled by lines from these, and from the ship.

It would probably be practicable under favorable circumstances —everything being quiet under the bow—to take the anchor directly from the hawse-pipe, as follows: A strap is put on the crown and the anchor is eased down until the crown is awash. The hanging-pendant is brought around and under the bilge of the boat and shackled to the strap. A kedge anchor is planted off the bow with a line for holding the boat clear. A wire hawser, technically known as a "veering-line," is shackled to the cable just forward of the 5-fathom shackle, taken to the winch, and hauled taut. The chain is now unshackled and the anchor is eased down by the veering-line until it hangs by the crown under the boat.

The veering-line may be left shackled to the chain on the

anchor and be sent out with the anchor as a hauling-line, or it may be unbent and replaced by another line. The length of cable which remains bent to the ring of the anchor takes the place of the lowering-rope and gives drift enough for unbending the veering-line.

Third Method—Plate **128**.

This resembles the Second Method, but with the difference that the hanging-pendant slides on the bight of the belly-strap and may thus be made very much shorter, as it can be slipped up to the water's edge, or above, and need only be long enough to admit being shackled to the eyes of the anchor strap.

As the anchor is lowered away, the eye of the hanging-pendant slides down until the anchor hangs below the keel. It is well to leave the belly-strap rather slack so that the eye may slide down freely.

The spreader is lashed to the thwart and the belly-strap seized temporarily to the spreader, as in the Second Method.

To make sure of recovering the belly-strap—which might unreeve after letting go—a light manila "doubling-line" may be passed around under the boat and bent to the ends of the belly-strap.

One possible disadvantage of this method is the fact that in a rough sea the anchor will slide back and forth on the belly-strap, as the boat rolls, and on an extreme roll might prove dangerous. This disadvantage may be overcome by the use of preventer lines.

Fourth Method—Plate **129**.

When it becomes necessary to carry out a very heavy anchor, like the bower of a battleship, the only practicable method is to put two motor-launches alongside and hang the anchor between them from a spar.

Here it is convenient to handle the anchor by the ring, bending the weighing-line independently to the crown. Except for this change, the anchor is handled substantially as in the methods already described.

The anchor is eased outside the hawse-pipe until the lowering-rope can be shackled to the ring. The strap is put on the crown

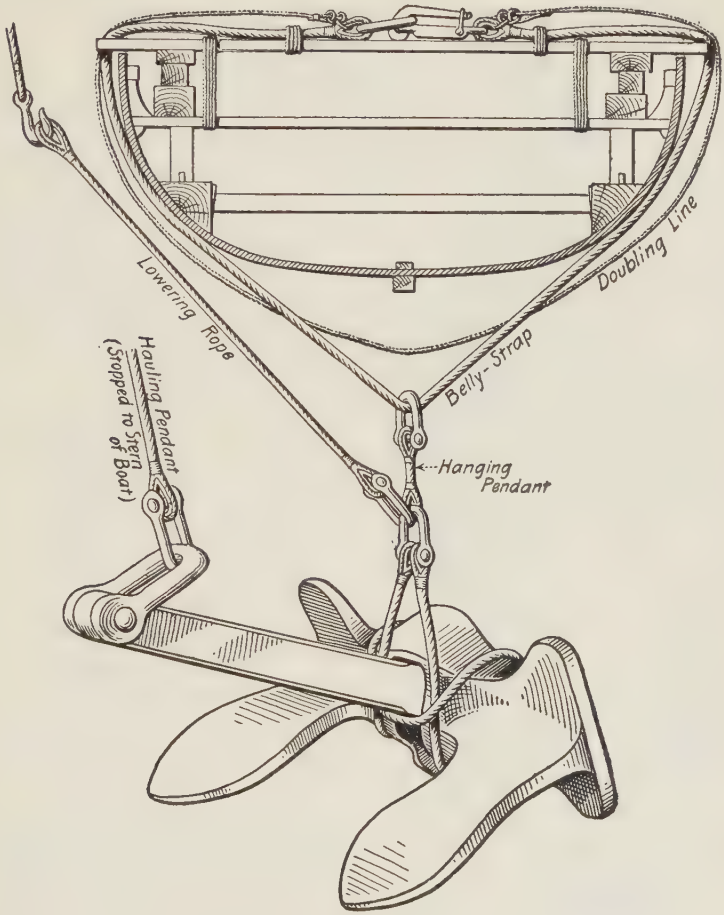


Fig. 1.

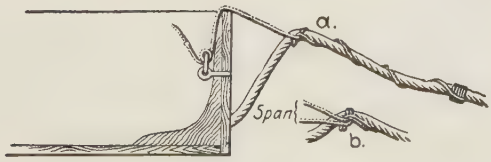


Fig. 2.

CARRYING OUT ANCHOR. THIRD METHOD

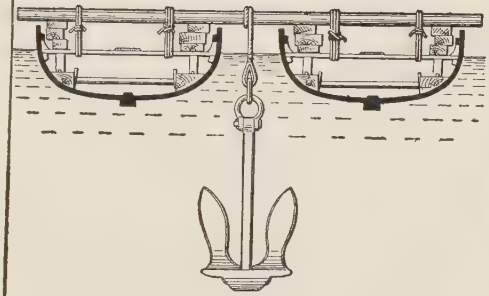


Fig. 2.

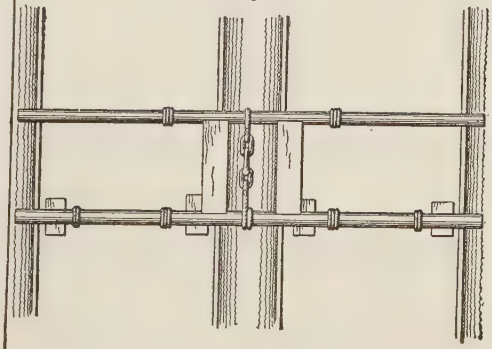


Fig. 3.

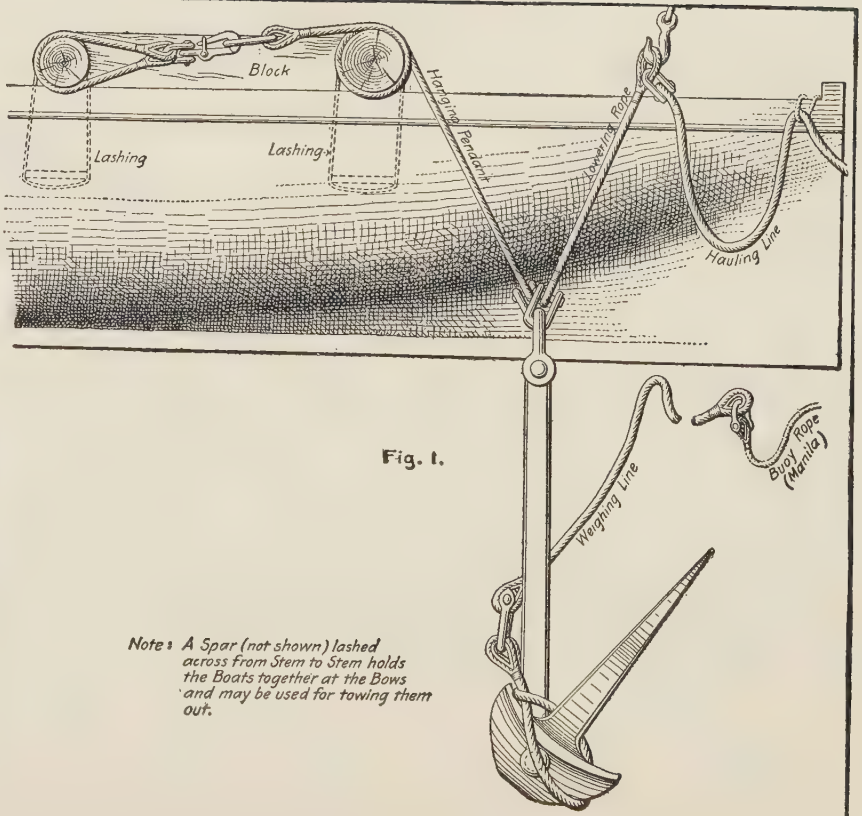


Fig. 1.

Note: A Spar (not shown) lashed across From Stem to Stem holds the Boats together at the Bows and may be used for towing them out.

CARRYING OUT ANCHOR - FOURTH

at the same time, and the weighing-line shackled to it. The chain is then veered, and the anchor swings to the lowering-rope.

In the meantime the boats have been prepared and hauled forward, and two kedge anchors planted where they will give the best control, with a line from each to the bows of the boats. A line from the stern of each boat to the ship completes the arrangement for holding the boats stern-on to the ship's side; provided, of course, that conditions make it desirable to hold the boats in this position. In any case it will be well to have at least one kedge anchor for holding the boats off, as the drag on the hanging-pendant while the anchor is being lowered into place will be very strong.

When the boats are held stern-on, the hanging-pendant is passed aft between them and shackled to the ring of the anchor at the water's edge. The chain is then unshackled, as has been described in connection with the Second Method, and the anchor is eased down into position, the lowering-rope passing between the boats, which will have a strong tendency to surge aft in obedience to the drag on the pendant.

The anchor may be handled by the crown instead of by the ring, without changing any principle of this method, and it will be convenient to adopt this plan if the water is rather shallow.

If the boats cannot be held stern-on, the hanging pendant must be dipped under the inner boat, as in the Second Method. Here a long pendant will be needed, and the anchor will necessarily hang rather deep. Assuming 10 feet for the beam of the boat, the pendant from the spar to the crown of the anchor would be approximately 16 feet, and allowing 4 feet more for the anchor makes a total depth of 20 feet. As a ship carrying boats of 10 feet beam would draw at least 28 feet normally, this should leave sufficient clearance between the anchor and the bottom.

The plan shown in Plate **129** for securing the hanging-pendant and letting go the anchor is very convenient, but it must be remembered that unless a turn is taken with the pendant around the spar, the strain on the spar will be approximately double the weight of the anchor, as the spar will in such a case play the part of a sheave. By taking a turn, this effect is greatly reduced.

It is well to make the slipping end of the pendant as short as

possible, to avoid the dangerous "whip" which would result from a long end when released.

Steadying-lines may be used from the flukes of the anchor, but they must be cast off before letting go.

The plan described in connection with the Second Method for taking the anchor from the hawse-pipe is equally applicable with the present method, subject to the limitations which have been pointed out with regard to the depth of water.

The boats may be towed out, or a kedge may be planted beyond the point where the bower is wanted, and the boats hauled out by a line from the kedge. Where conditions are unfavorable, as for example, where the boats must be hauled out against a strong wind or tide, it is a good plan to lash a large single block to the ring of the kedge and reeve through this a manila line. By bending one end of this line to the spar across the bows of the boats, and taking the other end on board the ship, the boats may be hauled out by the winch.

DIAMETER IN INCHES OF A ROUND SPAR OF A GIVEN SPAN, TO CARRY A GIVEN LOAD AT THE MIDDLE POINT

Safe load in pounds	Span in inches					
	18	24	30	36	42	48
6,000	6″.8	7″.4	8″.0	8″.3	8″.8	9″.0
8,000	7″.2	7″.9	8″.5	9″.0	9″.5	9″.9
10,000	7″.7	8″.5	9″.1	9″.7	10″.2	10″.7
12,000	8″.2	9″.0	9″.7	10″.3	10″.9	11″.4
14,000	8″.6	9″.5	10″.2	10″.9	11″.5	12″.0
16,000	9″.0	9″.9	10″.7	11″.4	12″.0	12″.5
18,000	9″.4	10″.3	11″.1	11″.8	12″.5	13″.0
20,000	9″.7	10″.7	11″.5	12″.2	12″.9	13″.5

A square beam the side of which is equal to the diameter of a round spar in the above table will support 1.7 times the load of the round spar. Conversely, a square beam to support a given load must have $^6/_{10}$ the thickness given above for a round spar.

The preceding table shows the size of spar required to carry a given weight, with a given distance between points of support. There is of course a difference in the strength of different varieties of wood, but the spars which are likely to be available on

shipboard are of about the same general character, and the figures here given, which are for good sound pine or spruce, may be used with confidence for all ordinary woods. Usually the most readily available and satisfactory spars to be found aboard ship are the boat booms.

The weight which can be carried varies directly with the cross-sectional area and inversely with the span; that is to say, the distance between points of support. A given spar spanning 24 inches between supports will carry twice as much as if the span were 48 inches.

Safe Floating Power of Navy Boats for 2nd, 3rd, and 4th Methods

Boat	Floating power	Remaining freeboard	
	Lbs.	*Inches*	
50-foot launch	24,000	28	
40 " "	16,000	28	In smooth water
36 " "	12,000	24	freeboard may be
33 " "	10,000	23	safely decreased.
30 " "	7,500	21	

Safe Floating Power at Stern with Compensating Weight at Bow

Boat	Load at stern if bow is loaded	Load at forward end of boat	Number of men required at forward end	Approximate remaining freeboard at stern
	Lbs.	*Lbs.*		*Inches*
50-foot launch	12,000	12,000	90	24
40 " "	8,000	8,000	65	24
36 " "	6,000	6,000	45	20
33 " "	4,500	4,500	35	18
30 " "	3,000	3,000	22	16

The weights in the bow should, if possible be men, and these should be grouped as far forward as is practicable. When the anchor is let go, the men must be prepared to move quickly aft, as the bow will dip suddenly.

To Pick Up an Anchor.

Where an anchor has been carried out for any purpose, it may be assumed that a weighing-line has been bent to the crown. In

which case the simplest way to pick up the anchor is to run a line from the ship to the end of the weighing-line and drag the anchor home, crown first. This plan greatly simplifies the matter of weighing an anchor which has been used for such temporary purposes as hauling the stern around for bore-sighting, for sub-caliber target practice, or for improving ventilation in a tropical climate.

If the conditions are such that the anchor cannot be hauled home by the ship, it must be weighed by a boat, and this should not be very difficult, if the anchor is of moderate size, and if it can be broken out by the crown. When no line has been provided from the crown, a diver should be sent down to bend one on.

To Weigh an Anchor by a Boat.

An anchor of medium size may be weighed by a boat by bringing the weighing-line in over the stern roller and applying a purchase to it. The flotation of the boat can be utilized to start the anchor, a convenient way being to fill the stern-sheets with men and heave the line well taut, then shift the men forward to the bow. By letting them "sally" forward on the run, the anchor may sometimes be jumped out. It is necessary to lift the anchor only far enough to permit carrying it back to the ship.

If there is no weighing-line from the crown of the anchor, and if circumstances do not permit sending down a diver to bend one on, the anchor must be broken out by the ring. In such a case, it is necessary to use a line from the ship, although a small anchor can be handled by a good-sized motor launch. A battle-ship motor launch should be able to deal with a 3000-pound anchor, and in some cases—when the anchor is not holding strongly—with one of double this size.

Lost Bower Anchor.

Where a bower anchor has been lost by the parting of a cable, it will usually happen that a certain length of chain is attached to the anchor. The problem is, in this case, for the ship to get hold of the chain and weigh the anchor with the windlass. This means, first of all, that the ship must place herself near the anchor, but not close enough to interfere with working lines from a boat. If the anchor is buoyed, it is located without difficulty.

If not, it must be found, and the easiest way to find it is to drag for the chain across the line on which it is supposed to lie. A grapnel may be used for dragging, but it is better to take a kedge anchor, to the stock of which a capstan-bar is lashed to keep the fluke down. The heavy bar near the jew's harp counteracts the tendency of the dragging line to point the jew's harp up in the direction of the pull, thus keeping the jew's harp down. The stock then directs a fluke into position on the bottom to snag the lost chain or anchor.

The chain having been grappled, it may be possible to lift the bight or the end and bend to it a line from the hawse-pipe, by which the ship can haul over and weigh the anchor. For this the boat that has found the chain would lift the bight, or hold on by the grapnel and send down a diver to shackle a line to the chain. If the chain is not long enough to bring the end inside the hawse, a strong wire line is shackled to a link near the end of the chain, but not to the end link. The end link must be left free for shackling to the cable on the ship.

Where the anchor to be handled weighs upward of ten tons, as do the bower anchors of a battleship, the following plan combines several advantages. It provides a perfectly manageable wire line to be shackled to any part of the anchor that can be reached, a length of chain-cable for shackling to the ship's cable, and an ample length of manila hawser for weighing the cable and the wire and for hauling the ship into place over the anchor. The plan is as follows:

A 5-fathom shot of chain is shackled at one end to a pendant of 1½-inch diameter wire eight or nine fathoms long, and the other end of the chain is shackled to a 6- or 7-inch manila hawser. The shot of chain and the wire pendant are slung outside a motor launch, the manila line is coiled in the stern sheets, and the boat proceeds to a point near the anchor. Here enough of the manila line is thrown over to reach the bottom, the chain is paid down on top of this, and lastly the wire pendant is paid down on top of all, where it is easy for the diver to handle it. The diving boat gets into position, and the diver goes down and shackles the wire pendant to any part of the anchor that he can reach conveniently. The motor launch takes the end of the manila line back to the ship, and it is hauled in through the hawse-pipe and taken to a winch.

The ship maneuvers into a position as nearly over the anchor as is practicable, and heaves in the manila line. When the chain comes in it is shackled to the free end of the cable on board and the anchor is hove up until the wire reaches the "wildcat," when the anchor is hung by a stopper, after which the cable is bent to the anchor and the wire pendant is removed.

If the water is too deep for diving, and the chain is not long enough to be picked up by grappling, the chances of recovering a stockless anchor are hardly worth considering.

With an old-fashioned anchor the case is quite different. Here the upper fluke may be caught by dragging the bight of a light chain, or of a rope weighted at two or more points, across the place where the anchor is known to lie. When the fluke is caught, a shackle may be put around the two parts of the dragging rope and allowed to slip down, thereby binding the two parts so that the line cannot become disengaged.

If the anchor is not buoyed, it may be assumed that its position can be fixed within narrow limits by bearings, and the first thing to be done will be to locate it exactly and to mark it by a buoy. Then proceed as before, utilizing a diver if practicable, or dragging for the bight of the chain. In all cases of dragging for an anchor or a chain it is important to mark by floats the area covered as the work progresses.

CHAPTER XII

THE RULES OF THE ROAD.

International Rules.

The present International Rules of the Road are an outgrowth of the Rules of the Road adopted in 1884 by Great Britain. These were adopted by the United States and were amended by an act of Congress in 1885. This brought about certain differences between the British and the United States rules.

In 1889, there was held in Washington, D. C., an International Marine Conference, for the purpose of securing greater safety for life and property at sea. The rules adopted by this Conference have been in effect for many years.

The International Rules of 1889 definitely state:

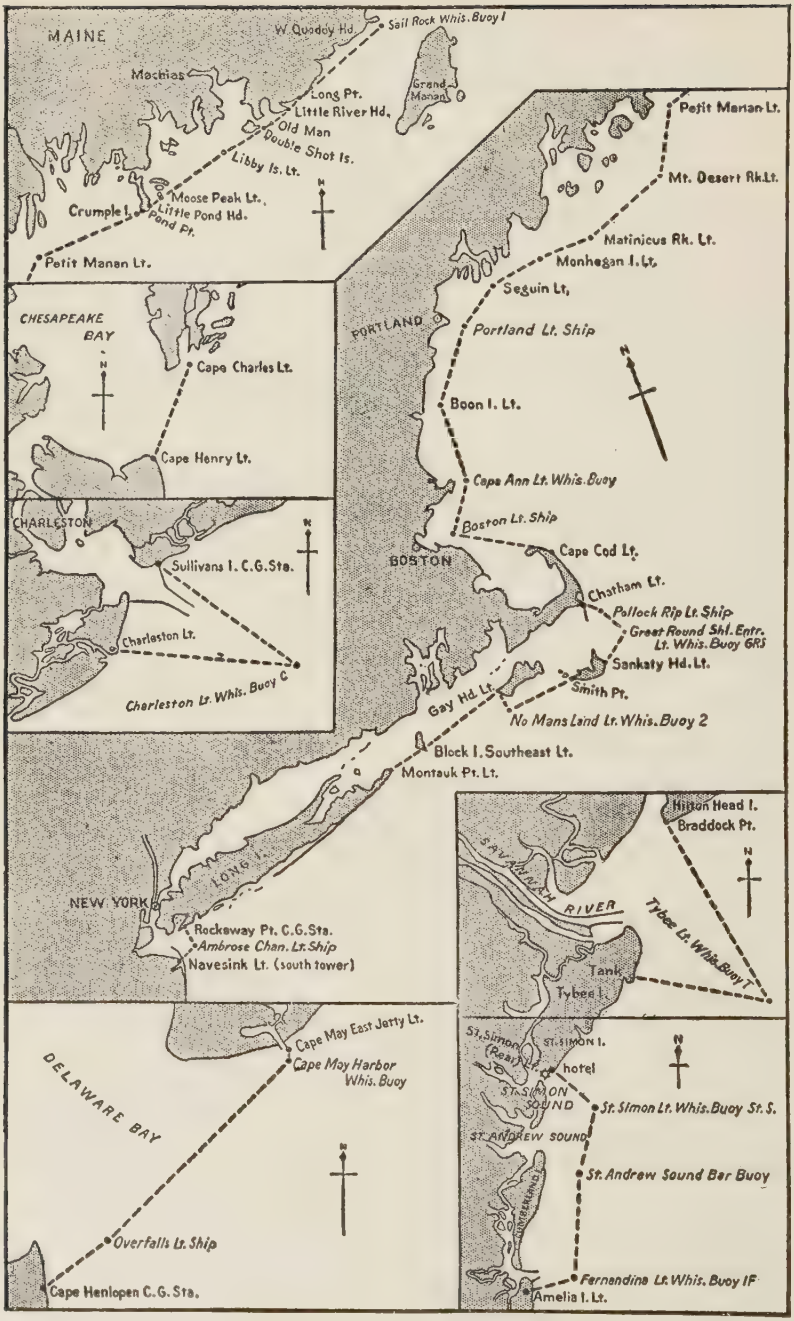
"Art. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river or inland waters."

Inland Rules.

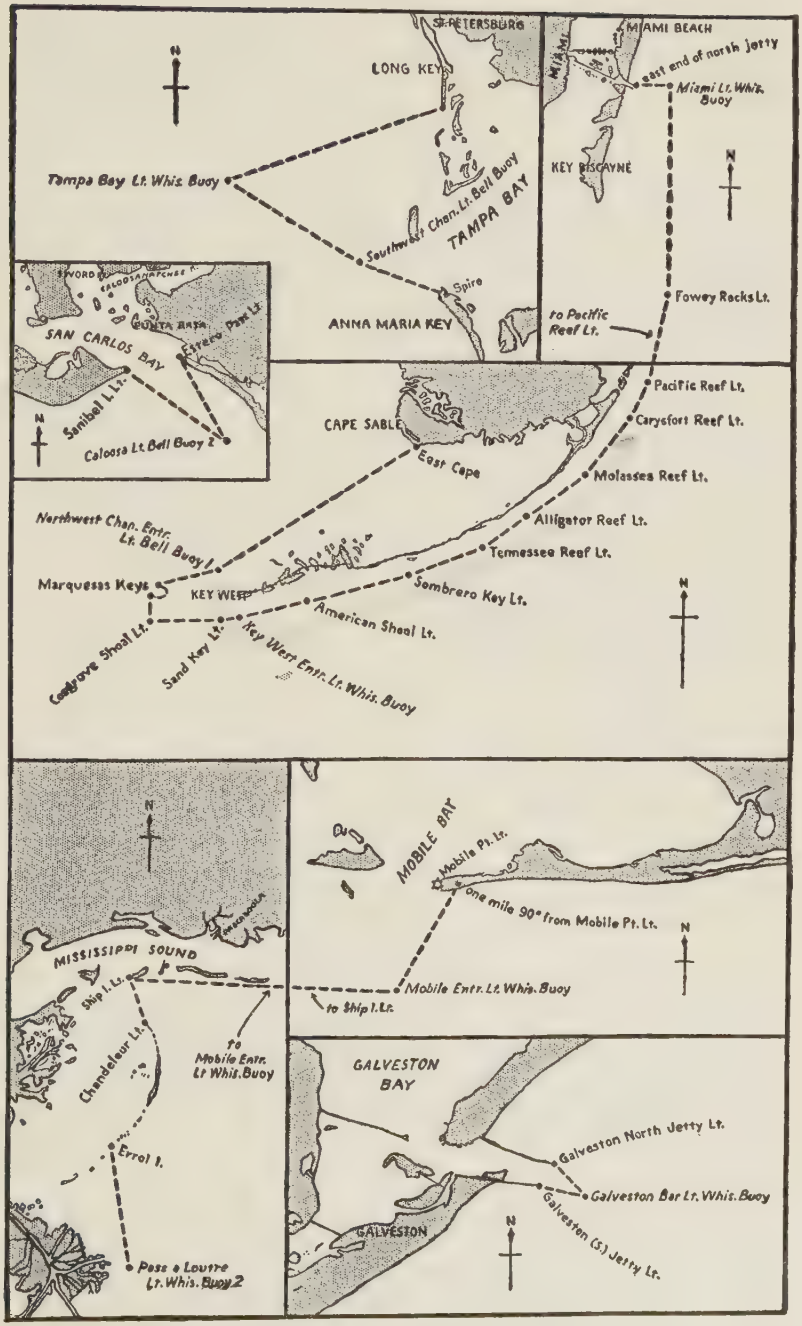
In accordance with Article 30 of the International Rules, the Congress of the United States in 1897 passed "An act to adopt regulations for preventing collisions upon certain harbors, rivers, and inland waters of the United States." This Act has been amended from time to time and contains the Inland Rules of the Road.

The Act of Congress mentioned in the foregoing paragraph contained the following:

Sec. 2. That the supervising inspector of steam vessels and the Supervising Inspector General shall establish such rules to be observed by steam vessels in passing each other and as to the lights to be carried by ferryboats and by barges and canal boats when in tow of steam vessels, and as to the lights and day signals to be carried by vessels, dredges of all types, and vessels working on wrecks by (or) other obstruction to navigation or moored for submarine operations, or made fast to a sunken object which may drift with the tide or be towed, not inconsistent with the provisions of this Act, as they from time to time may deem necessary for safety, which rules when approved by the Secretary of Commerce are hereby declared special rules duly made by local authority, as provided for in article thirty of chapter eight hundred and two of the laws of eighteen hundred and ninety. Two printed copies of such rules shall



BOUNDARIES BETWEEN INTERNATIONAL AND INLAND WATERS.



BOUNDARIES BETWEEN INTERNATIONAL AND INLAND WATERS.

be furnished to such ferryboats, barges, dredges, canal boats, vessels working on wrecks, and steam vessels, which rules shall be kept posted up in conspicuous places in such vessels, barges, dredges, and boats.

Pilot Rules.

In accordance with Section 2 above, the Supervising Inspector General (Board of Steamboat Inspectors) has drawn up additional rules, known as Pilot Rules. The Pilot Rules are divided into three distinct sections:

(*a*) Pilot Rules for all harbors, rivers, and inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal, and the Red River of the North and rivers emptying into the Gulf of Mexico and their tributaries.

(*b*) Pilot Rules for the rivers whose waters flow into the Gulf of Mexico and their tributaries and the Red River of the North.

(*c*) Pilot Rules for the Great Lakes and their connecting and tributary waters.

In addition to the above, there are Local Rules for foreign waters, some of which may be found in Sailing Directions but more generally must be obtained from local authorities.

The penalty for violation of the Inland and Pilot Rules is contained in the Act of Congress which set forth the Inland Rules.

Sec. 4. That every vessel that shall be navigated without complying with the provisions of this Act shall be liable to a penalty of two hundred dollars, one-half to go to the informer, for which sum the vessel so navigated shall be liable and may be seized and proceeded against by action in any district court of the United States having jurisdiction of the offense.

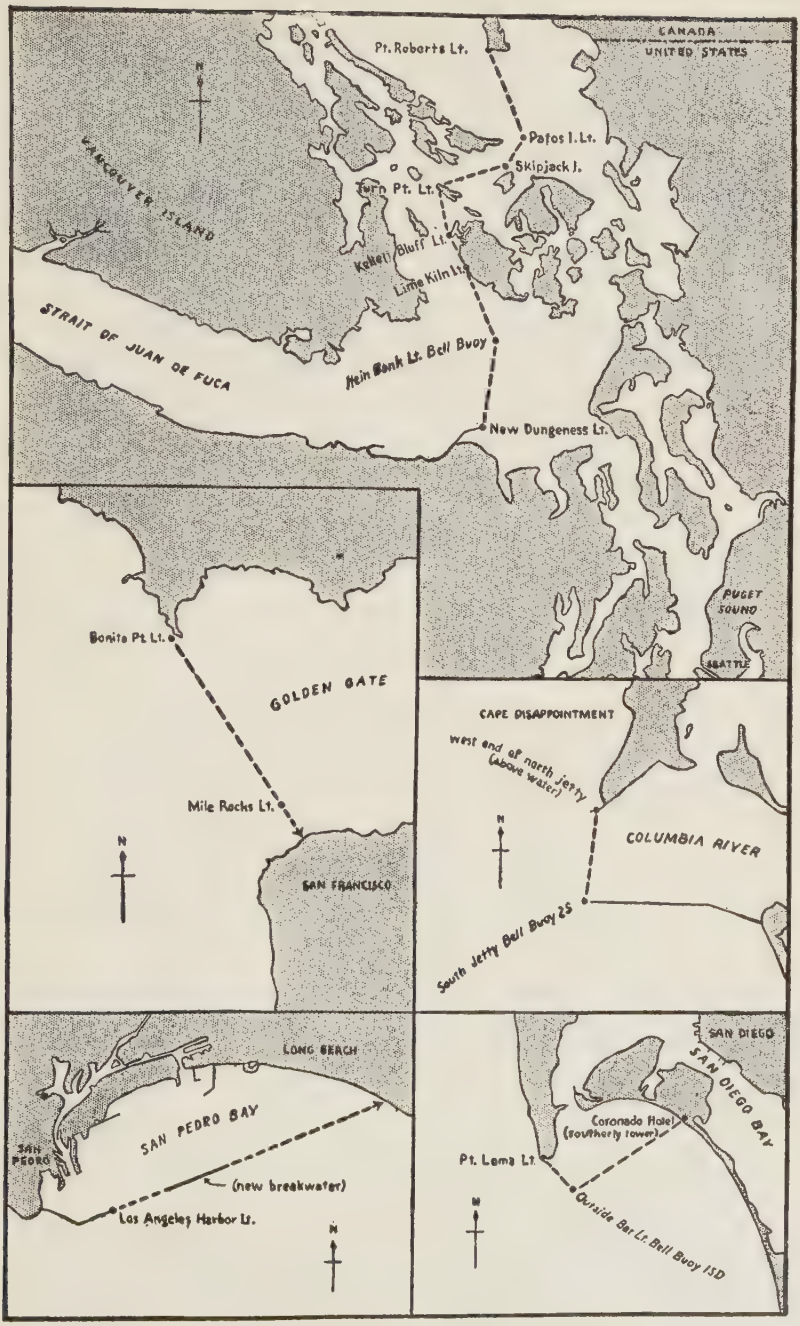
The boundary line between International Waters and Inland Waters has been determined by the Board of Steamboat Inspectors in accordance with Section 2. The boundary is set forth in Plates 130, 131, and 132.

The International and Inland Rules are printed together as a Department of Commerce Circular (No. 230) and may be procured at any office of the Bureau of Navigation or Steamboat Inspection Service.

The Pilot Rules for Great Lakes and their connecting Tributary waters, the Pilot Rules for the Red River of the North and rivers flowing into the Gulf of Mexico are separate publications and may be procured from the same source.

General.

There is no subject with which the mariner should be more familiar than with the Rules of the Road. Lack of knowledge not only endangers the ship, but it endangers all those on board whose lives have been entrusted to the Captain and officers handling the vessel.



BOUNDARIES BETWEEN INTERNATIONAL AND INLAND WATERS.

The rules are obligatory, whether they be International, Inland or Pilot. The only possible exception is, that should the Pilot Rules in any case contradict the Inland Rules, then the latter are the ones to be obeyed. Pilot Rules are made by the Board of Supervising Inspectors, Steamboat Inspection Service, under the authority of the Act of Congress which created the Inland Rules and hence the Pilot Rules may not legally contradict the Inland Rules. The Navigator may not apply them at his convenience. The courts have stressed the mandatory nature of the rules.

Size gives no privilege. The rules apply equally to large and small vessels or to sailing vessels and steam vessels.

> **In the Svea, Wilson** *v.* **Pacific Mail S. Co.,** 276 U.S. 454; the court held in part, as follows: "Big vessels may not insolently disregard smaller ones; super-size gives no right to domineer."

It is not sufficient that the rules be ultimately obeyed. Obedience to the rules must be timely. They must be obeyed in time to avoid the risk of collision. It is illegal to wait until danger is imminent before complying with the rules. The question of timely obedience has entered into numerous court decisions.

> **In the Carrol, 8 Wall. 302,** the Supreme Court held: "The safeguards against danger, in order to be effectual, must be seasonably employed, and in this case they were not used until the danger was threatening."

> **In New York, etc., Co.** *v.* **Rumball,** 21 How. 372: "Rules of Navigation . . . are obligatory upon vessels approaching each other from the time the necessity for precaution begins."

> **In The Clara,** 49 Fed. 765, it was held: "Timely signals are required, because such signals tend to avert the natural consequences of carelessness, and the lack of previous timely observation on one side or the other, as well as to enable the boats to come to a common understanding as to mode of passing."

In discussing the two vessels whose relation to each other is such as to involve risk of collision, seamen usually speak of the "privileged vessel" and the "burdened vessel." The "privileged vessel" is the one which, by the rules is required to hold course and speed, while the "burdened vessel" is the one required by the rules to keep clear. It must be understood that the terms "privileged" and "burdened" are not used in their literal sense, for the "privileged vessel" is also responsible for carrying out the rules and her actions are definitely set forth by the rules.

> **The Straits of Dover,** 120 Fed. 900, "The privileged vessel should have kept her course and speed unless in case of imminent danger, and the *Bluefields* (burden vessel) had the right to as-

sume that she would do so, and in case of emergency justifying a departure therefrom, should have followed strictly the rule (art. 28, sounding the proper signals) governing such maneuver, which she failed to do."

Aircraft operating on the water are classed as ships and must obey the Rules of the Road.

In the following pages the International Rules and the Inland Rules are printed in parallel columns. The Pilot Rules are embodied at the points where they apply. They are, in fact, a part of the Inland Rules, since they derive their authority from a clause in the law enacted by Congress establishing the Inland Rules.

Preliminary Definitions.

In the following Rules every steam vessel which is under sail and not under steam is to be considered a sailing vessel, and every vessel under steam, whether under sail or not, is to be considered a steam vessel.

The words "steam vessel" shall include any vessel propelled by machinery.

A vessel is "under way" within the meaning of these rules, when she is not at anchor, or made fast to the shore, or aground.

LIGHTS, AND SO FORTH.

The word "visible" in these Rules when applied to lights, shall mean visible on a dark night with a clear atmosphere.

Art. 1. The Rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights or impair their visibility shall be exhibited.

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Art. 1. The Rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

The lights required under the following articles must be burned from sunset to sunrise whether underway or at anchor. The fact that there may be sufficient visibility during this time to see another vessel at a distance of several miles is not a valid excuse for failure to burn the lights during such periods.

The fact that the required lights are burning and showing through the required arc and for the required distance at sunset is not the end of the ship's responsibility. They must be kept burning in accordance with the law and in case of a failure of any required light, it must be immediately replaced. Stand-by lights should be at hand, ready to light. The occasion when it is necessary to send below for a replacement light will probably be just the time when the failure to show all the required lights will mislead another vessel.

The lights must show through the required arcs and failure to so locate them will establish presumption of guilt on the offending vessel in case of collision. Not only must they be so located as to show through the correct arc, but care must be taken that nothing is permitted to obscure them.

In the present days of electric running and anchor lights on most ships, little difficulty should be experienced in having the lights visible the required distance. However, this must be checked, so that the bulb used is of sufficient intensity and the lenses clear. Should oil lights be used, the necessity for seeing that the lenses are clean and wicks trimmed is obvious.

The watch officer at sea, should be insistent upon receiving the half hourly reports that the running lights are burning and should frequently check them himself. Upon the sighting of another vessel it is well for the watch officer to check up personally his running lights. At anchor, the necessity for assuring himself that the proper lights are burning is no less than when underway. It is easier to forget the lights required at anchor than to forget those required underway.

The Federal courts have held, in regard to the liability for carrying of improper lights, that the ship that has improper lights is liable. This was held in **The Romuk,** 120 Fed. 841, in **The Royal Arch,** 22 Fed. 457, and in **The Mary Lord,** 26 Fed. 862.

In **The Mary Lord,** 26 Fed. 862, the court held as follows: "The other vessel was deceived and misled by this failure * * * the fault, then, being wholly on the part of the vessel libeled, there must be a decree accordingly."

In **The Clendinin** *v.* **The Steamship Alhambra,** 4 Fed. 86, the court held: "That lights so arranged as to mislead an approaching vessel, in regard to the course she was pursuing, renders a vessel liable."

In **The Titan,** 23 Fed. 413, the court held: "The rules requiring lights may as well be disregarded altogether as to be only partially complied with, and in a way which fails to be of any real service in indicating to another vessel the position and course of the one carrying them."

In **Atlantic Coast Co.** *v.* **United States,** 13 Fed. (2d) 354: "Failing to have or show a stern light, or to use a flare light, breached article 10 of the International Rules and the schooner held in fault."

In **The Iberia,** 117 Fed. 718, 123 Fed. 865: "The **Carib** (barkentine) was grossly in fault for so arranging her lights and sails that upon occasions there would be a considerable field of obstruction."

Lights for Steam Vessels.

Steam Vessels—Masthead Light.

Art. 2. A steam vessel when under way shall carry—

(*a*) On or in front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, a bright white light, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

Steam Vessels—Side Lights.

(*b*) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(*c*) On the port side a red light so constructed as to show an unbroker light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(*d*) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Steam Vessels—Range Lights.

(*e*) A steam vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (*a*). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the

Lights for Steam Vessels.

Art. 2. A steam vessel when under way shall carry: (*a*) On or in front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, *a bright white light*, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least *five miles*.

Steam Vessels—Side Lights.

(*b*) *On the starboard side a green light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least *two miles*.

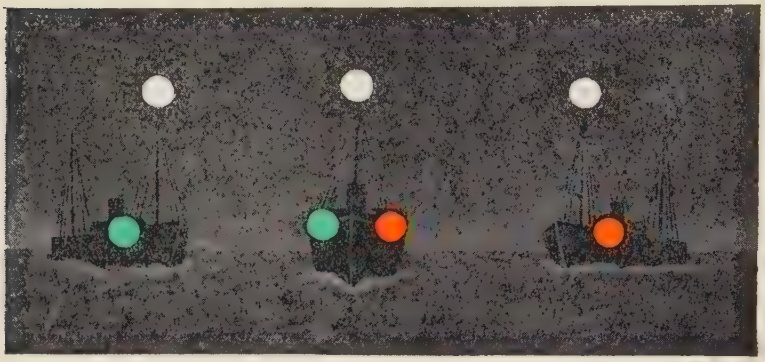
(*c*) *On the port side a red light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least *two miles*.

(*d*) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Steam Vessels—Range Lights.

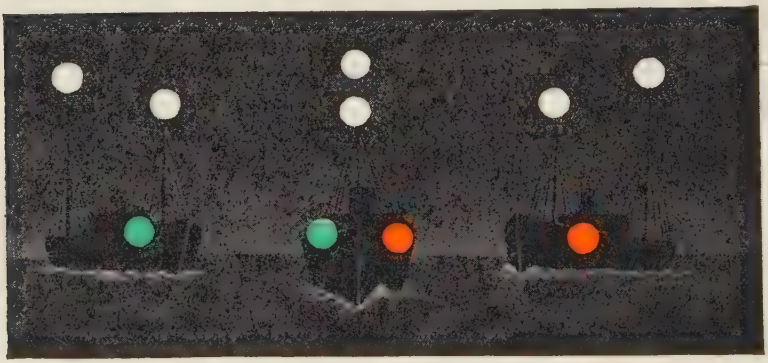
(*e*) A seagoing steam vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (*a*). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher

other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.



INTERNATIONAL

Steamer Without Range Lights.



INTERNATIONAL AND INLAND

Steamer With Range Lights.

than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

(*f*) All steam vessels (except seagoing vessels and ferryboats), shall carry in addition to green and red lights required by article two (*b*), (*c*), and screens as required by article two (*d*), a central range of two white lights; the after light being carried at an elevation of at least fifteen feet above the light at the head of the vessel. The headlight shall be so constructed as to show an unbroken light through twenty points of the compass, namely, from right ahead to two points abaft the beam on either side of the vessel, and the after light so as to show all around the horizon.

The forward light required under Article 2(*a*) International Rules or Inland Rules, is generally spoken of as the mast-head light. It will be noted that while the characteristics of the light are the same under both rules, its height is specified within certain limits under International Rules but that the Inland Rules fail to lay down any limitations as to its height.

The after light mentioned in (*e*) of the International Rules and the after light in (*f*) of the Inland Rules is usually known as a range light. Under International Rules this is a 20-point light and under Inland Rules a 32-point light.

Another difference is that no distance of visibility for the range light is specified under the Inland Rules, whereas it must be visible for *five miles* under International Rules.

Range lights are of inestimable value in determining a ship's course at night and for that reason most seagoing vessels have been carrying them for years. Taken in consideration with the red and green side lights, the fact that the central range of lights is in line or the amount they are open will give a close approximation of a vessel's course. In addition, they will immediately show any change in course, its direction and approximate angle, by the amount the range lights open or close.

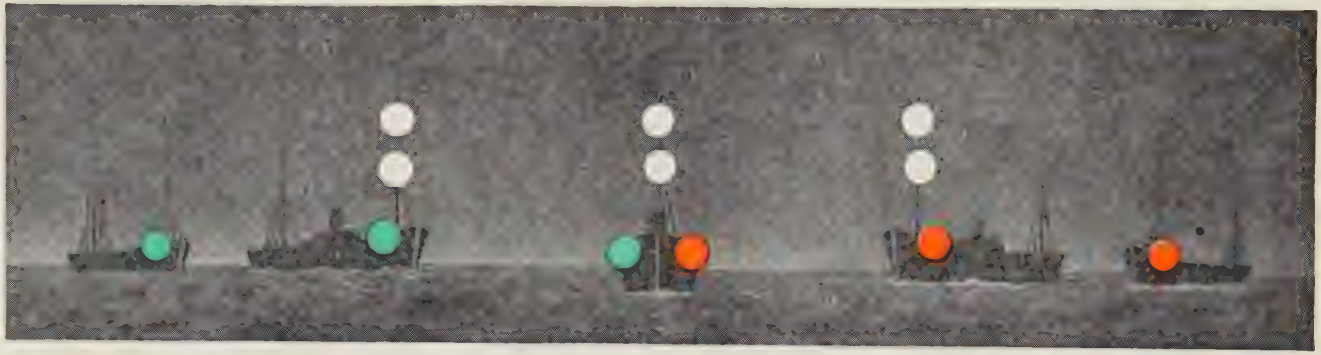
Steam Vessels—When Towing.

Art. 3. A steam vessel when towing another vessel shall, in addition to her side lights, carry two bright white lights in a vertical line one over the other, not less than six feet apart, and when towing more than one vessel shall carry an additional bright white light six feet above or below such lights, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in Article 2 (*a*), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.

Such steam vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

INTERNATIONAL.

TOWING MORE THAN ONE VESSEL. (Length of tow exceeding 600 feet.)



INTERNATIONAL.

TOWING ONE VESSEL. (Or more than one if length not exceeding 600 feet.)

STEAMER TOWING WITHOUT RANGE LIGHTS.

INTERNATIONAL AND INLAND

Towing More than One Vessel. (Length of tow exceeding 600 feet.)

INTERNATIONAL

Towing One Vessel. (Or more than one if length not exceeding 600 feet.)

STEAMER TOWING WITH RANGE LIGHTS.

Steam Vessels—When Towing.

Art. 3. A steam vessel when **towing** another vessel or vessels alongside shall, in addition to her side lights, carry *two bright white lights* in a vertical line, one over the other, not less than three feet apart, and when towing one or more vessels astern, regardless of the length of the tow, shall carry *an additional bright white light* three feet above or below such lights: PROVIDED, that on the Red River of the North and the rivers emptying into the Gulf of Mexico and their tributaries this article shall not affect the signal lights used on towing vessels which propel the tow by pushing at the rear of the tow. (Approved May 20, 1936.) Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in Article 2 (*a*) or the after range light mentioned in Article 2 (*f*).

Such steam vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

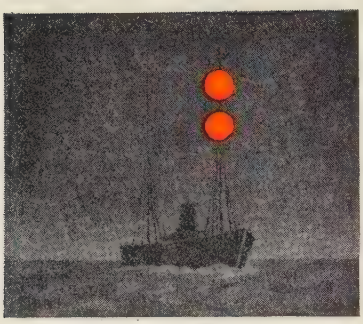
The wording of the International Rule for towing lights often causes confusion as to when to carry two or three lights. This doubt may be dispelled if it is noticed that in order to carry three lights, two conditions must be fulfilled—the total length of tow must be over 600 feet and there must be more than one vessel in tow. If these two conditions are not met only two towing lights are to be displayed.

Under International Rules the towing lights must be located in the fore part of the vessel and they must be twenty point, five mile lights with the lowest at least fourteen feet above the hull.

The Inland Rules are quite different from the International Rules. When towing alongside, only two lights are to be used regardless of the number of tows. When towing astern, three lights are to be used regardless of the length of the tow or the number of vessels in the tow.

In either case, whether towing alongside or astern, the lights may be carried either forward or aft. If carried forward, one of the towing lights is in lieu of the masthead light and all are twenty point lights. If carried aft, one of the lights is in lieu of the range light and all are thirty-two point lights.

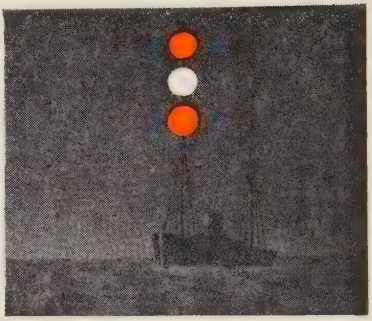
The question of whether the towing vessel or the towed vessel is responsible for the lights being properly set on the tow and in accordance with the law is dependent upon the facts of the case rather than upon any specific rule. If the tow, as in the case of larger vessels, hires tugs to assist her and remains in charge of operations, then certainly, the



INTERNATIONAL

Carries Side Lights, if Making Way thru Water.

VESSEL NOT UNDER COMMAND.



Carries Side Lights, if Making Way thru Water.

VESSEL WORKING WITH TELEGRAPH CABLE.

Special Lights.

Art. 4. (*a*) A vessel which from any accident is not under command shall carry at the same height as a white light mentioned in Article 2 (*a*), where they can best be seen, and if a steam vessel in lieu of that light two red lights, in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than six feet apart, where they can best be seen, two black balls or shapes, each two feet in diameter.

(*b*) A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as the white light mentioned in Article 2 (*a*), and if a steam vessel in lieu of that light three lights in a vertical line one over the other not less than six feet apart. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all around the horizon, at a distance of at

master of the larger vessel is responsible. However, in a case such as the towing of barges, where the entire operation is in charge of the master of the towing vessel, the master of that vessel is responsible for the burning of proper lights by the towed vessel(s), as well as his own, but this does not relieve the towed vessel of her own responsibilities. In some cases it is not so easy to place the responsibility and the contract entered into between the two would determine if either was solely responsible or if there existed joint responsibility.

In the case of **Elmhurst-Socony,** 1935 A.M.C., 295, 10 Fed. Supp. 341, decided in the United States District Court for the Southern District of New York, it was held:

> "In the suit brought by the city against the barge and the towing tug for damages to the ferryboat, the damages will be divided into thirds, one-third attributable to the ferryboat, one-third to the barge and one-third to the tug. The absence of proper lights on the barge is a fault not only of the barge but also of the towing tug. **Nettie L. Tice,** 110 Fed. 461 (EDNY); **Sif,** 266 Fed. 166 (8CCA). It makes no difference that the barge and the tug were owned by the same party, the libel being in rem * against both barge and tug and the fault being viewed as that of the vessel themselves as separate offenders. **Eugene F. Moran,** 212, U. S. 466. In this suit, therefore, the city is entitled to two-thirds of the damage done to the ferryboat, one-third from the barge and one-third the tug."

* "in rem" means against the ship.

least two miles. By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, three shapes not less than two feet in diameter, of which the highest and lowest shall be globular shape and red in color, and the middle one diamond in shape and white.

(*c*) The vessels referred to in this article, when not making way through the water, shall not carry the side lights, but when making way shall carry them.

(*d*) The lights and shapes required to be shown by this article are to be taken by other vessels as signals that the vessel showing them is **not under command** and cannot therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in Article 31.

Article 4 was omitted from the Inland Rules as it was considered that it would not be necessary in inland navigation. In order to keep the corresponding numbers between the articles of the International and Inland Rules no article numbered 4 was included in the act of Congress establishing the Inland Rules. The article having been omitted, a vessel in Inland waters, not under command, or laying or picking up a submarine cable, would carry the lights of a vessel of her class.

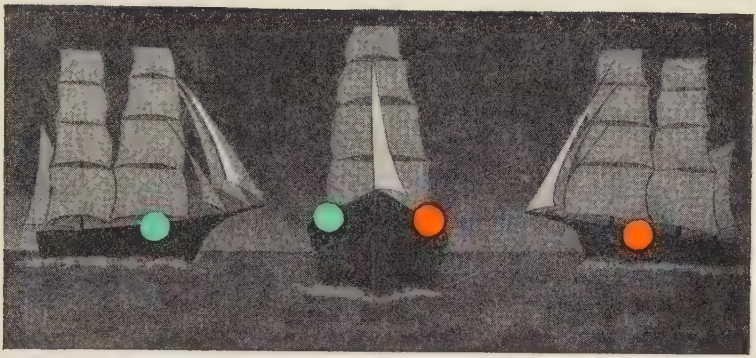
Under International Rules, a vessel not under command due to reasons other than accident, carries the lights of a vessel of her class.

While the lights mentioned in Article 4 are in lieu of the masthead and range lights, it is not required that any one of them be located in the same position as the masthead or range light. They shall be located where they can best be seen and the lowest shall be at least fourteen feet above the hull.

The vessels mentioned in Article 4 show no lights other than the ones prescribed in (*a*) or (*b*) and Art 10, unless actually making way through the water, when side-lights are to be exhibited. Under paragraph (*d*) of the article, all other vessels are required, by inference, to keep clear of them, therefore, the requirements as to side-lights is logical. If one vessel must keep clear of another which is hampered in her movements, it is essential that the giving-way vessel know whether or not the other is dead in the water or making way.

Lights for Sailing Vessels and Vessels in Tow.

Art. 5. A sailing vessel under way, and any vessel being towed, shall carry the same lights as are prescribed by Article 2 for a steam vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.



INTERNATIONAL OR INLAND RULES

A Sailing Vessel.

Lights for Sailing Vessels and Vessels in Tow.

Art. 5. **A sailing vessel under way and any vessel being towed,** except barges, canal boats, scows, and other vessels of nondescript type, when in tow of steam vessels, shall carry the same lights as are prescribed by Article 2 for a steam vessel

Lights for Small Vessels.

Art. 6. Whenever, as in the case of small vessels under way during bad weather, the green and red side lights cannot be fixed, these lights shall be kept at hand lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides.

under way, with the exception of the white lights mentioned therein, which they shall never carry.

Sec. 2. That the Board of Supervising Inspectors of Steam Vessels shall establish such rules to be observed by steam vessels in passing each other and as to the lights to be carried by ferry-boats and by barges and canal boats when in tow of steam vessels, (and as to the lights and day signals to be carried by vessels, dredges of all types, and vessels working on wrecks by [or] other obstruction to navigation or moored for submarine operations, or made fast to a sunken object which may drift with the tide or be towed) not inconsistent with the provisions of this act, as they from time to time may deem necessary for safety, which rules when approved by the Secretary of Commerce are hereby declared special rules duly made by local authority, as provided for in Article 30 of Chapter 802 of the laws of 1890. Two printed copies of such rules shall be furnished to such ferryboats (barges, dredges, canal boats, vessels working on wrecks) and steam vessels, which rules shall be kept posted up in conspicuous places in such vessels (barges, dredges, and boats).

Note.—Section 2 above is a restatement of that section as found in the enacting clause of the Act of Congress establishing the Inland Rules.

Under this article of both rules, a sailing vessel underway and any vessel being towed shall carry side-lights, but not the masthead and range lights required of steamers.

Such part of the Pilot Rules drawn under the authority of Section 2 of the Enacting Clause of Inland Rules and referred to in Article 5 of the Inland Rules, as have wide application, will be found at the end of this Chapter.

Lights for Small Vessels.

Art. 6. Whenever, as in the case of **vessels of less than ten gross tons** under way during bad weather, the green and red side lights cannot be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Art. 7. Steam vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned in Article 2 (*a*), (*b*), and (*c*), but if they do not carry them they shall be provided with the following lights:

First. Steam vessels of less than forty tons shall carry—

(*a*) In the fore part of the vessel, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in Article 2 (*a*), and of such a character as to be visible at a distance of at least two miles.

(*b*) Green and red side lights constructed and fixed as prescribed in Article 2 (*b*) and (*c*), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing a green light and a red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second. Small steamboats, such as are carried by seagoing vessels, may carry the white light at a less height than nine feet above the gunwale, but it shall be carried above the combined lantern mentioned in Subdivision 1 (*b*).

Third. Vessels under oars or sails of less than twenty tons shall have ready at hand a lantern with a green glass on one side and a red glass on the other, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fourth. Rowing boats, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be obliged to carry the lights prescribed by Article 4 (*a*) and Article 11, last paragraph.

To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Art. 7. **Rowing boats,** whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

"On April 25, 1940, the President of the United States approved Public Law No. 484, 76th Congress, which repealed the Motorboat Act of June 9, 1910, and provided for the better protection of life and property, increasing the standards for licensing of operators, fire and lifesaving equipment, ventilation, and other safety devices."

Public Law No. 484, 76th Congress, which might be properly termed the Motorboat Act of April 25, 1940, follows:—

"Sec. 1. The words "motorboat" include every vessel propelled by machinery and not more than sixty-five feet in length except tug boats and tow boats propelled by steam.

"Sec. 2. Motorboats subject to the provisions of this Act shall be divided into four classes as follows:

"*Class A.* Less than sixteen feet in length.

"*Class 1.* Sixteen feet or over and less than twenty-six feet in length.

"*Class 2.* Twenty-six feet or over and less than forty feet in length.

"*Class 3.* Forty feet or over and not more than sixty-five feet in length.

"Sec. 3. That every motorboat in all weathers from sunset to sunrise shall carry and exhibit the following lights, when underway and during such time no other lights which may be mistaken for those prescribed shall be exhibited:

"(*a*) Every motorboat of Classes A and 1 shall carry the following lights:

"First. A bright white light aft to show all around the horizon.

"Second. A combined lantern in the fore part of the vessel and lower than the white light aft showing green to starboard and red to port, so fixed as to throw the light from right ahead to two points abaft the beam on their respective sides.

"(*b*) Every motorboat of Classes 2 and 3 shall carry the following lights:

First. A bright white light in the fore part of the vessel as near the stem as practicable, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely from right ahead to two points abaft the beam on either side.

Second. A bright white light aft to show all around the horizon, and higher than the white light forward.

Third. On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side. On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side. Said lights shall be fitted with inboard screens of sufficient height and so set as to prevent these lights from being seen across the bow.

"(*c*) Motorboats of classes 2 and 3, when propelled by sail and machinery, or by sail alone, shall carry the colored side lights, suitably screened, but not the white lights prescribed by this section: Provided, however, That motorboats of all classes, when so propelled, shall carry, ready at hand, a lantern or flashlight showing a white light which shall be exhibited in sufficient time to avert collision: Provided further, That motorboats of Classes A and 1, when so propelled, shall not be required to carry the combined lantern prescribed by subsection (*a*) of this section.

"(*d*) Every white light prescribed by this section shall be of such character as to be visible at a distance of at least two miles. Every colored light prescribed by this section shall be of such character as to be visible at a distance of at least one mile. The word "visible" in this Act, when applied to lights, shall mean visible on a dark night with clear atmosphere.

"SEC. 4. Every motorboat of class 1, 2, or 3, shall be provided with an efficient whistle or other sound-producing mechanical appliance.

"SEC. 5. Every motorboat of class 2 or 3 shall be provided with an efficient bell."

SEC. 6 (life preservers).

SEC. 8 (fire extinguishers).

Sec. 10 (carburetor back-fire traps).

Sec. 11 (ventilating bilges).

"Sec. 13. No person shall operate any motorboat or any vessel in a reckless manner so as to endanger the life, limb, or property of any person.

"Sec. 14. Any person who shall operate any motorboat or any vessel in a reckless or negligent manner so as to endanger the life, limb, or property of any person shall be deemed guilty of a misdemeanor and on conviction thereof by any court of competent jurisdiction shall be punished by a fine not exceeding $2,000, or by imprisonment for a term of not exceeding one year, or by both such fine and imprisonment, at the discretion of the court."

The Inland Rules have been so modified by this Act, that all vessels of not more than sixty-five feet in length and propelled by machinery are classed as motorboats rather than steam vessels, unless they be tugboats or towboats, propelled by steam.

Under the rules, yachts of not more than sixty-five feet operating in Inland waters would be required to comply with the Motorboat Act, but should they go upon the high seas, they would be required to comply with Article 7 of the International Rules.

Lights for Pilot Vessels.

Art. 8. Pilot vessels when engaged on their station on pilotage duty shall not show the lights required for other vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

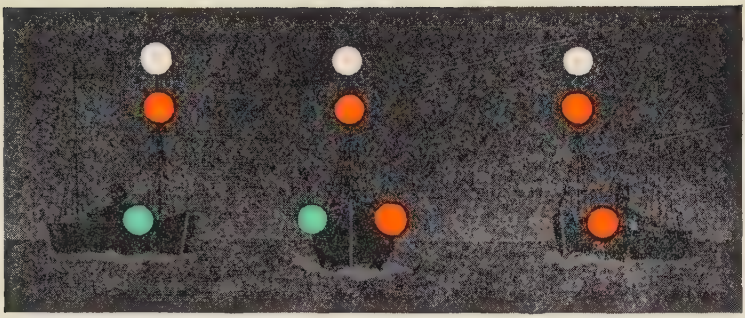
On the near approach of or to other vessels they shall have their side lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above mentioned, have at hand, ready for use, a lantern with green glass on the one side and red glass on the other, to be used as prescribed above.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

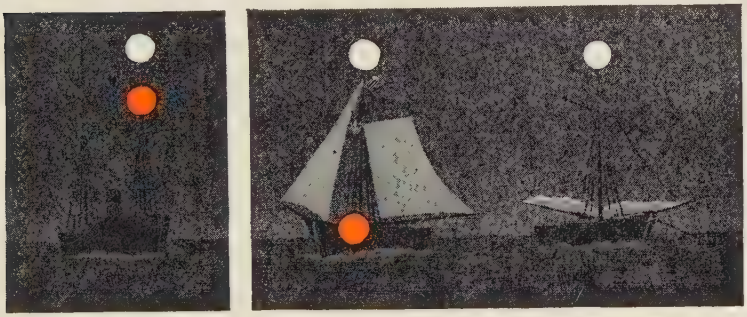
A steam pilot vessel, when engaged on her station on pilotage duty and in waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a red light, visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry in addition to the lights required for all pilot boats the red light above mentioned, but not the colored side lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam vessels.



INTERNATIONAL AND INLAND

STEAM PILOT VESSEL UNDER WAY, U. S. WATERS.



INTERNATIONAL AND INLAND

AT ANCHOR. U.S. WATERS. STEAM PILOT VESSEL.

UNDER WAY. (*Shows Flare-up at Intervals;*) (" *Side-Lights* " ") SAILING PILOT VESSEL.

AT ANCHOR ON DUTY. (*Shows Flare-up at Intervals.*)

Lights for Pilot Vessels.

Art. 8. **Pilot vessels** when engaged on their stations on pilotage duty shall not show the lights required for other vessels, but shall carry a *white light at the masthead,* visible all around the horizon, and shall also exhibit a *flare-up light* or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above mentioned, have at hand, ready for use, a lantern with a green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

A steam pilot vessel, when engaged on her station on pilotage duty and in waters of the United States, and *not at anchor,* shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a *red light,* visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored *side lights* required to be carried by vessels under way.

When engaged on her station on pilotage duty and in waters of the United States, and *at anchor,* she shall carry in addition to the lights required for all pilot boats the *red light* above mentioned, but not the colored side lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam vessels.

Steam pilot-vessels under both rules must carry side-lights when under way. Sailing pilot-vessels need not continuously show side-lights when under way, but must have them ready for use and shall flash them on the near approach of or to other vessels to indicate their heading.

The location of the white light of a pilot-vessel should be noted. It is carried at the masthead and not at the position of the light mentioned in Article 2 (*a*) and commonly known as a masthead light.

Lights, etc., of Fishing Vessels.

Art. 9. Fishing vessels and fishing boats, when under way and when not required by this article to carry or show the lights hereinafter specified, shall carry or show the lights prescribed for vessels of their tonnage under way.

(*a*) Open boats, by which is to be understood boats not protected from the entry of sea water by means of a continuous deck, when engaged in any fishing at night, with outlying tackle extending not more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry one all-round white light.

Open boats, when fishing at night, with outlying tackle extending more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry one all-round white light, and in addition, on approaching or being approached by other vessels, shall show a second white light at least three feet below the first light and at a horizontal distance of at least five feet away from it in the direction in which the outlying tackle is attached.

(*b*) Vessels and boats, except open boats as defined in subdivision (*a*), when fishing with drift nets, shall, so long as the nets are wholly or partly in the water, carry two white lights where they can best be seen. Such lights shall be placed so that the vertical distance between them shall be not less than six feet and not more than fifteen feet, and so that the horizontal distance between them, measured in a line with the keel, shall be not less than five feet and not more than ten feet. The lower of these two lights shall be in the direction of the nets, and both of them shall be of such a character as to show all around the horizon, and to be visible at a distance of not less than three miles.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the net or gear) a white light, visible at a distance of not less than one sea mile, on the approach of or to other vessels.

(*c*) Vessels and boats, except open boats as defined in subdivision (*a*), when line fishing with their lines out and attached to or hauling their lines, and when not at anchor or stationary

Lights, etc., of Fishing Vessels.

Art. 9. (*a*) **Fishing vessels of less than ten gross tons**, when under way and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side lights; but every such vessel shall, in lieu thereof, have ready at hand a lantern with a green glass on one side and a red glass on the other side, and on approaching to or being approached by another vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

(*b*) All fishing vessels and fishing boats of ten gross tons or upwards, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

(*c*) All vessels, when **trawling, dredging, or fishing with any kind of drag-nets or lines**, shall exhibit, from some part of the vessel where they can be best seen, *two lights*. One of the lights shall be *red* and the other shall be *white*. The red light shall be *above the white light*, and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all round the horizon, the white light a distance of not less than three miles and the red light of not less than two miles.

(*d*) Rafts, or other water craft not herein provided for, navigating by hand power, horse power, or by the current of the river, shall carry one or more good white lights, which shall be placed in such manner as shall be prescribed by the Board of Supervising Inspectors of Steam Vessels.

The lights to be carried by fishing vessels under the International Rules differ for various methods of fishing, but under Inland Rules, the same lights are carried by all fishing vessels, that is, a thirty-two point red light over a thirty-two point white light. In no case do vessels showing the special lights for fishermen show any side-lights.

A distinction is drawn in Article 9 of the International Rules between two important methods of fishing. *Trawlers, dredgers,* and *drag-net* fishers run usually with the tide, dragging a net or scoop along the bottom. Their speed, under favorable circumstances, rarely exceeds two or three knots, and their power of maneuvering is of course very limited.

within the meaning of subdivision (*h*), shall carry the same lights as vessels fishing with drift nets. When shooting lines or fishing with towing lines they shall carry the lights prescribed for a steam or sailing vessel under way, respectively.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the lines) a white light, visible at a distance of not less than one sea mile on the approach of or to other vessels.

(*d*) Vessels when engaged in trawling, by which is meant the dragging of an apparatus along the bottom of the sea—

First. If steam vessels, shall carry in the same position as the white light mentioned in Article 2 (*a*) a tri-colored lantern so constructed and fixed as to show a white light from right ahead to two points on each bow, and a green light and a red light over an arc of the horizon from two points on each bow to two points abaft the beam on the starboard and port sides, respectively; and not less than six nor more than twelve feet below the tri-colored lantern a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon.

Second. If sailing vessels, shall carry a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon, and shall also, on the approach of or to other vessels, show where it can best be seen a white flare-up light or torch in sufficient time to prevent collision.

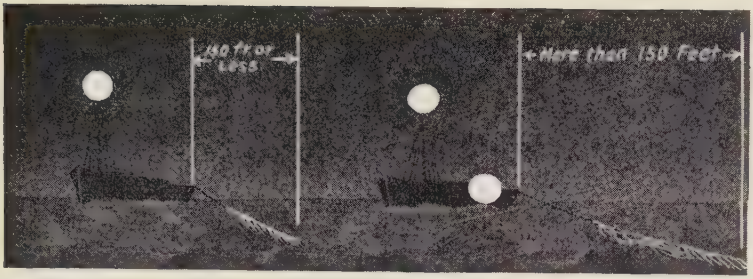
All lights mentioned in subdivision (*d*), first and second, shall be visible at a distance of at least two miles.

(*e*) Oyster dredgers and other vessels fishing with dredge nets shall carry and show the same lights as trawlers.

(*f*) Fishing vessels and fishing boats may at any time use a flare-up light in addition to the lights which they are by this article required to carry and show, and they may also use working lights.

(*g*) Every fishing vessel and every fishing boat under one hundred and fifty feet in length, when at anchor, shall exhibit a white light visible all around the horizon at a distance of at least one mile.

Every fishing vessel of one hundred and fifty feet in length or



INTERNATIONAL.
OPEN BOATS.

INTERNATIONAL
STEAM TRAWLER.

INTERNATIONAL.
LINE FISHING. DRIFT NET FISHING.

INTERNATIONAL.
SAILING TRAWLER OR DREDGE. ANY FISHING VESSEL AT ANCHOR AND ATTACHED TO FISHING GEAR.

VESSELS' LIGHTS.

These vessels are usually of considerable size and their work is carried on in deep water and often at great distances from shore. If the trawl or dredge catches on the bottom, the vessel is virtually at anchor, and shows the regular anchor lights.

Fishing by *drift-nets* and *lines* is carried on by vessels drifting and, of course, unable to maneuver for the avoidance of collision.

Drift-nets are laid out with the wind and the vessel rides head to wind to leeward of her nets, which may be as much as two miles in length, stretching off to windward, and buoyed at certain distances. *Lines* are laid out across the tide, and may be six or eight miles in length, marked at intervals by small buoys carrying flags. These buoys are not to float the line, but only to mark it. At the end of the line is a light anchor or other weight, which drags along the bottom, keeping the lines well down but not holding the boat.

Drift-net fishing is principally done by night, line fishing by day, trawling by both night and day.

The methods of fishing to which this article applies are carried on by many thousands of vessels along the coasts of Europe north of Cape Finisterre, in certain parts of the Mediterranean, and in the waters of China and Japan.

All fog signals under the Inland Rules are found under Article 15 of those rules. There being no special fog signals for fishing vessels under the Inland Rules, fishing vessels subject to the rules sound the fog signals for vessels of their class.

Article 9 (*i*) of the International Rules prescribes special fog signals for vessels fishing. Article 9 (*h*) states that should a fishing vessel become stationary by reason of gear getting fast to a rock or other obstruction, she shall sound the signal prescribed by Article 15 (*d*) or 15 (*f*).

Mine-Sweeping Operations

United States vessels engaged in mine-sweeping operations or exercises are hampered to a considerable extent in their maneuvering powers.

Vessels Must Keep Clear of Mine Sweepers

With a view to indicating the nature of the work on which they are engaged, these vessels will show the signals hereinafter mentioned. For the public safety all other vessels, whether steamers or sailing craft, should endeavor to keep out of the way of vessels displaying these signals and not approach them inside the distances mentioned herein, especially remembering that it is dangerous to pass between the vessels of a pair or group sweeping together.

All vessels towing sweeps are to show:

By day—A black ball at the fore masthead and a black ball at each yardarm.

By night—All around green lights instead of the black balls, and in a similar manner. (These lights may only be exhibited when necessary to warn approaching friendly ships.)

Vessels or formations showing these signals are not to be approached nearer than 500 yards on either beam and ships are not to cross astern closer than 1,000 yards. In no circumstances is a ship to pass through a formation of mine sweepers.

Mine sweepers should be prepared to warn merchant vessels who persist in approaching too close by means of any of the appropriate signals from the International Code of Signals.

upward, when at anchor, shall exhibit a white light visible all around the horizon at a distance of at least one mile, and shall exhibit a second light as provided for vessels of such length by Article 11.

Should any such vessel, whether under one hundred and fifty feet in length or of one hundred and fifty feet in length or upward, be attached to a net or other fishing gear, she shall on the approach of other vessels show an additional white light at least three feet below the anchor light, and at a horizontal distance of at least five feet away from it in the direction of the net or gear.

(*h*) If a vessel or boat when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall in daytime haul down the day signal required by subdivision (*k*); at night show the light or lights prescribed for a vessel at anchor; and during fog, mist, falling snow, or heavy rainstorms make the signal prescribed for a vessel at anchor. (See subdivision (*d*) and the last paragraph of Article 15.)

(*i*) In fog, mist, falling snow, or heavy rainstorms drift-net vessels attached to their nets, and vessels when trawling, dredging, or fishing with any kind of drag net, and vessels line fishing with their lines out, shall, if of twenty tons gross tonnage or upward, respectively, at intervals of not more than one minute make a blast; if steam vessels, with the whistle or siren, and if sailing vessels, with the foghorn, each blast to be followed by ringing the bell. Fishing vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals; but if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

(*k*) All vessels or boats fishing with nets or lines or trawls, when under way, shall in daytime indicate their occupation to an approaching vessel by displaying a basket or other efficient signal where it can best be seen. If vessels or boats at anchor have their gear out, they shall, on the approach of other vessels, show the same signal on the side on which those vessels can pass.

The vessels required by this article to carry or show the lights hereinbefore specified shall not be obliged to carry the lights prescribed by Article 4 (*a*) and the last paragraph of Article 11.

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being overtaken by another shall show from her stern to such last-mentioned vessel a white light or a flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side lights.

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length, **when at anchor**, shall carry forward, where it can *best* be seen, but at a height not exceeding twenty feet above the hull, a *white light* in a lantern so constructed as to show a clear, uniform, and unbroken light visible all round the horizon at a distance of at least one mile.

A vessel of one hundred and fifty feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty, and not exceeding forty feet above the hull, *one such light*, and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, *another such light*.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel aground in or near a fairway shall carry the above light or lights and the two red lights prescribed by Article 4 (*a*).

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being **overtaken** by another, except a steam vessel with an after range light showing all around the horizon, shall show from her stern to such last-mentioned vessel *a white light or a flare-up light.*

Under the International Rules and Inland Rules the carrying of a fixed overtaken light by a seagoing steamer is optional. The use of flare up or other white light shown to the overtaking vessel meets the requirements of the law. However, the questions of how soon the overtaken vessel showed the light, or whether or not a view of it was obstructed, and how long it was shown have been the source of much litigation.

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length **when at anchor,** shall carry forward, where it can *best* be seen, but at a height not exceeding twenty feet above the hull, a *white light* in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile:

"Provided that the Secretary of War may, after investigation, by rule, regulation, or order, designate such areas as he may deem proper as "special anchorage areas"; such special anchorage areas may from time to time be changed, or abolished, if after investigation the Secretary of War shall deem such change or abolition in the interest of navigation: Provided further, That vessels not more than sixty-five feet in length when at anchor in any such special anchorage area shall not be required to carry or exhibit the white light required by this article.

"Act of Congress approved April 22, 1940."

A vessel of one hundred and fifty feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, *one such light,* and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, *another such light.*

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

Pilot Rule 6.

Vessels of more than three hundred gross tons propelled by machinery, when moored or anchored in a fairway or channel where traffic is liable to congestion or confusion, shall display between sunrise and sunset on the forward part of the vessel where it can best be observed from other vessels, one black ball or shape not less than two feet in diameter.

It is to be noted that by the Pilot Rules sailing vessels are not required to show the black ball when at anchor.

Special Signals.

Art. 12. Every vessel may, if necessary in order to attract attention, in addition to the lights which she is by these Rules required to carry, show a flare-up light or use any detonating signal that cannot be mistaken for a distress signal.

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Art. 12. Every vessel may, if necessary, in order to attract attention, in addition to the lights which she is by these Rules required to carry, show a *flare-up light* or use any detonating signal that cannot be mistaken for a distress signal.

The International Rules, Article 12, do not permit the use of any attention signal other than a flare-up light or detonating signal. The use of the whistle as an attention signal is not provided for.

The purpose of the Article may best be stated by quoting Mr. Charles Hall, of Great Britain, a delegate to the Conference of 1889. In discussing the rule Mr. Hall said: "What we propose is that every ship may at any time, in addition to the lights which she is by these regulations required to carry, show a flare-up light, or use a detonating signal to attract attention. I think this will be of great use to sailing vessels. But we propose it as of assistance to both sailing vessels and steamers. It may be of advantage to steam vessels, because if by chance the sidelights should be obscured, as has been pointed out by the delegate from France, has occurred in many instances, then the steamer will have the additional assistance of the flare-up light or the detonating signal to make her aware of the presence in the vicinity of a vessel out of the way of which she has to keep."

The signal mentioned in Article 12 should not be confused with the flare-up light which may be used as an overtaken light under Article 10 of the Inland Rules. The light is intended to be shown forward to attract attention.

The question of when "it is necessary" to show or give the signal will, of course, depend upon conditions and judgment of the person using it. However, in the case of a collision where, in the opinion of the court, it was necessary and not made, it is probable that the court would attach blame to the vessel for its failure.

Article 12 of the Inland Rules is identical with Article 12 of the International Rules. The lack of any whistle signal is not a disadvantage to steamers as the danger signal under Rule III of Article 18 fully covers the use of a whistle signal which may be needed under the conditions anticipated by Article 12.

Naval Lights and Recognition Signals.

Art. 13. Nothing in these Rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by shipowners, which have been authorized by their respective Governments and duly registered and published.

Steam-vessels under Sail by Day.

Art. 14. A steam vessel proceeding under sail only, but having her funnel up, shall carry in daytime, forward, where it can best be seen, one black ball or shape two feet in diameter.

SOUND SIGNALS FOR FOG, AND SO FORTH.

Preliminary.

Art. 15. All signals prescribed by this article for vessels under way shall be given:

First. By "steam vessels" on the whistle or siren.

Second. By "sailing vessels" and "vessels towed" on the fog horn.

The words "prolonged blast" used in this article shall mean a blast of from four to six seconds' duration.

A steam vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn, to be sounded by mechanical means, and also with an efficient bell. In all cases where the rules require a bell to be used a drum may be substituted on

Naval Lights and Recognition Signals.

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The purpose of Article 13 is so obvious that it requires but little discussion.

Under the Article each U. S. Man-of-War, when steaming in company, carries a light at the mainmast head. The light is known as a speed light and by its color and whether a fixed or flashing light, indicates to the vessels in company just what speed the ship is making. It should not be confused with the range light under Article 2(e) of the rules. Men-of-war when steaming singly use the range light, a twenty-point light, optional under Article 2(e).

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The words "prolonged blast" used in this article shall mean a blast *of from four to six seconds' duration.*

A steam vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn; also with an efficient bell. A sailing vessel of twenty tons gross tonnage or upward shall be provided with a similar fog horn and bell.

board Turkish vessels, or a gong where such articles are used on board small seagoing vessels. A sailing vessel of twenty tons gross tonnage or upward shall be provided with a similar fog horn and bell.

In a fog, mist, falling snow, or heavy rainstorms, whether by day or night, the signals described in this article shall be used as follows, namely:

Steam Vessel Under Way.

(*a*) A steam vessel having way upon her shall sound, at intervals of not more than two minutes, a prolonged blast.

(*b*) A steam vessel under way, but stopped, and having no way upon her, shall sound, at intervals of not more than two minutes, two prolonged blasts, with an interval of about one second between.

Sail Vessel Under Way.

(*c*) A sailing vessel under way shall sound, at intervals of not more than one minute, when on the starboard tack, one blast; when on the port tack, two blasts in succession, and when with the wind abaft the beam, three blasts in succession.

Vessels at Anchor or Not Under Way.

(*d*) A vessel when at anchor shall, at intervals of not more than one minute, ring the bell rapidly for about five seconds.

Vessels Towing or Towed.

(*e*) A vessel when towing, a vessel employed in laying or in picking up a telegraph cable, and a vessel under way, which is unable to get out of the way of an approaching vessel through being not under command, or unable to maneuver as required by the Rules, shall, instead of the signals prescribed in subdivisions (*a*) and (*c*) of this article, at intervals of not more than two minutes, sound three blasts in succession, namely: One prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

In fog, mist, falling snow, or heavy rainstorms, whether by day or night, the signals described in this article shall be used as follows, namely:

(*a*) A steam vessel **under way** shall sound, at intervals of not more than one minute, *a prolonged blast.*

(*b*) . . .

(*c*) **A sailing vessel** under way shall sound, at intervals of not more than one minute, when on the *starboard tack, one blast*; when on the *port tack, two blasts* in succession, and when with the *wind abaft the beam, three blasts* in succession.

(*d*) A vessel when **at anchor** shall, at intervals of not more than one minute, *ring the bell rapidly for about five seconds.*

(*e*) *A steam vessel* when **towing** shall, instead of the signals prescribed in subdivision (*a*) of this article, at intervals of not more than **one** minute, sound *three blasts in succession, namely, one prolonged blast followed by two short blasts.* **A vessel towed** may give this signal and she shall not give any other.

(*f*) All rafts or other water craft, not herein provided for, navigating by hand power, horse power, or by the current of the river, shall sound a blast of the fog horn, or equivalent signal, at intervals of not more than one minute.

Under both rules a prolonged blast is here defined as a blast of four to six seconds' duration. Under Article 28 of the International Rules and under the Pilot Rules a short blast is defined as a blast of about one second's duration.

The fog signals prescribed by Article 15 of the International and Inland Rules and Article 9 (*i*) of the International Rules are the only signals to be sounded during fog, mist, falling snow or heavy rain unless vessels come within sight of each other. After coming within sight even though they be in a fog, the sound signals to be used are those set forth elsewhere for vessels in sight of each other.

The location of the whistle or siren so that the sound may not be intercepted by any obstruction is difficult, due to masts and stacks. However, the usual location of the whistle or siren on the forward side of a large stack is not the best. Such location intercepts, to some extent, through several points of the compass, the sound of the whistle. The latest United States battleships have the whistles installed under the tops of the foremast—an excellent location.

Small Sailing Vessels and Boats.

Sailing vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals, but, if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

Under both rules a steam vessel under way, with way upon her, sounds one prolonged blast on the whistle, the maximum interval between blasts in the International Rules being two minutes and the maximum interval under the Inland Rules being one minute.

There is no paragraph 15 (*b*) under the Inland Rules and therefore a steam vessel in Inland waters being under way, with no way upon her, shall sound the signal of a steamer under way; namely, one prolonged blast on the whistle at intervals of not more than one minute.

Under International Rules, Article 15 (*b*), a steam vessel under way with no way upon her shall sound two prolonged blasts on the whistle at intervals not exceeding two minutes. This signal is not to be sounded at the moment of stopping the engines. The signal of one prolonged blast shall be sounded until the vessel is dead in the water. While all way is off the ship, the signal of two prolonged blasts shall be sounded.

Fog signals for sailing vessels under way are found in paragraph (*c*). The signal for the tack a vessel was on shall be sounded until she is away on the new tack. The fog signal of a sailing vessel at sea and becalmed is that of a vessel not under command. Under Inland Rules a sailing vessel becalmed sounds the signal for the tack she is on.

In addition to the signals of one, two or three blasts on the fog horn, the International Rules (not Inland Rules) provide for a sailing vessel not under command, laying or picking up a submarine cable, or towing. These cases would be rare; but, should they occur, the sailing vessel would sound one prolonged and two short blasts on the fog horn at intervals not exceeding two minutes, Article 15 and 15 (*e*).

Fog signals must be sounded not only when a vessel is in a fog but when running close to a fog bank and before actually entering the fog.

In the case of the **Papoose-Wright**, 1936 A.M.C., 1126, Justice Chase of the Circuit Court of Appeals stated as follows:

> "The serious matter is the failure of the *Wright* to sound fog signals. Though she was not actually in the fog, she was running along a heavy bank but 300 yards distant out of which a ship might emerge at any time as the *Papoose* in fact did. Both the Inland Rules (33 Mason's U.S.C., sec. 191) and the International Rules (33 Mason's U. S. C., sec. 91) provide that ships must sound signals as described 'In fog, mist, falling snow, or heavy rainstorms, whether by day or night . . . Compliance requires the sounding of the signals by a vessel not only when she is herself in the fog but is so close to it that her position should be made known to a vessel which the fog might be hiding. William H. Taylor, 278 Fed. (2CCA); Perkiomen, 27 Fed. 573 (D. C.). In view of these decisions the argument here made that there was no positive breach of the statute cannot be treated as sound."

When vessels are moored alongside one another each vessel must sound the appropriate fog signal as required by the Rules.

The International Marine Conference of 1889 spent many hours con-

Speed of Ships to Be Moderate in Fog, and so Forth.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a moderate speed, having careful regard to the existing circumstances and conditions.

A steam vessel hearing, apparently forward of her beam, the fog signal of a vessel the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

sidering the fog signal for a vessel towed. The question was whether or not the signal for vessels in tow should be optional or mandatory. It was decided that in busy harbors where there are many tows made up of numerous vessels, there would be bedlam if the signal were mandatory for all vessels of the tow. The signal was, therefore, made optional. The Inland Rule was drawn in accordance with the rule set forth by the Conference of 1889, that is, one prolonged followed by two short blasts on the fog horn.

It is interesting to note that the International Rules group the vessel towing in a fog with the vessel not under command and the vessel laying or picking up a submarine cable. However, if they come within sight of a steam vessel, even though they be in a fog, the steamer is the burdened vessel in relation to the vessel not under command and the vessel laying or picking up submarine cable under Article 4; but, the relation of the steamer and the vessel towing is governed by the ordinary steering and sailing rules and the Rule of Good Seamanship.

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a moderate speed, having careful regard to the existing circumstances and conditions.

A steam vessel hearing, apparently forward of her beam, the fog signal of a vessel the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

The International Marine Conference of 1889 adopted this Article as it stands today, after much discussion. Several delegates were insistent that instead of using the words "moderate speed" a speed in knots should be set forth.

One delegate suggested that the allowed speed be made to depend upon horse power and displacement. The reasons for failure to adopt a definite speed in knots were well expressed by a United States delegate, Mr. Goodrich, in addressing the Conference. He said in part:

> ". . . Now Mr. President, in the flexibility of this rule is its safety. Its flexibility permits a man to adapt his speed according to circumstances; and the duty which is put upon him by this rule is that he shall comply with it according to the circumstances under which he finds himself placed." And again the same delegate said: "But, as the learned delegate from Germany said: the law which applies to an unfrequented part of the ocean does not apply to a crowded fairway; and that shows how limited is our capacity to draw a rule which shall define absolutely all cases, and to express the duty which is to be imposed upon vessels; because moderate speed in one case, is immoderate speed in another. Moderate speed in a light fog may be immoderate speed in a dense fog. Moderate speed in an unfrequented part of the ocean may be an immoderate speed in a crowded fairway. So you will find it impossible to lay down a definite rule as to what moderate speed means under all the different and differing circumstances in which vessels will find themselves placed."

Probably no point in the Rules of the Road has been more frequently interpreted by the courts than the question of moderate speed in a fog.

A few of the many court decisions are quoted:

In the case of **Aalsum-Dannedaike**, 1929 A.M.C. 650, 32 Fed. (2) tried before the Circuit Court of Appeals, Chief Justice Hand stated on this subject of speed in a fog under international rules, as follows:

> "We are concerned only with the faults of the *Aalsum,* which are charged to be, first, an 'immoderate' speed, and, second, failing to stop her engines upon hearing the *Dannedaike's* signals, both violations of Article 16, as it has stood since 1889. The first depends upon whether she could stop her way with such visibility as existed after sighting another vessel. *Nacoochee* 137 330; *Manchioneal,* 243 Fed. Rep. 801 (2CCA); *Haven,* 277 Fed. Rep. 957 (2CCA); *Esperanza,* 1927 A.M.C. 230, 16 F (2d) 945. That duty is, however, correlative with the duty of the other vessel to do the same. *Umbria,* 166 U.S. 404. The rule is not theoretically adequate in all cases; though each vessel be in such reserve that she can check her way before she reaches the place at which the other appears, it does not follow that they cannot collide. The point of meeting may be such that they will both reach it, though each

have stopped before reaching the place where she could first have sighted the other. However, it is the only practicable rule and it is the law."

The Nacoochee, 137 U. S. 330, in which the Supreme Court held: "She was bound to observe unusual caution, and to maintain only such a rate of speed as would enable her to come to a standstill, by reversing her engines at full speed, before she should collide with a vessel which she should see through the fog."

Justice Brown (an acknowledged expert in admiralty), in the **Umbria**, 166 U. S. 404, stated the rule as follows: "The general consensus of opinion in this country is to the effect that a steamer is bound to use only such precautions as will enable her to stop in time to avoid a collision, after the approaching vessel comes in sight, provided such approaching vessel is herself going at the moderate speed required by law. In a dense fog this might require both vessels to come to a standstill until the course of each was definitely ascertained. In a lighter fog it might authorize them to keep their engines in sufficient motion to preserve their steerageway."

The district court, in the **Luella** *v.* **Rosedale**, decided in September, 1927, held as follows: "The *Luella* was not proceeding with reasonable caution and was at fault. For her to have proceeded at the rate that she did (10 knots) up through the Bristol Channel in a dense fog when she could not see ahead at the most over 100 yards, particularly after hearing fog signals, leaves no doubt as to her speed being excessive; she was far from being able to stop or take the necessary means to avoid a collision within the distance which her lookout could see."

In **The Haven**, 277 Fed. 957, the court said: "A vessel navigating in a fog must go no faster than will permit her to stop within the distance she can see ahead."

In **The City of Norfolk**, 266 Fed. 641, the court said: "In such navigation, moderate speed means speed so slow that the vessel can be stopped within the distance at which another vessel can be seen."

After considering the quoted decisions and others, the conclusions may be drawn that the United States courts have defined moderate speed in a fog as that speed which will permit a vessel in a fog to stop within the distance she can sight an approaching vessel. This may require the vessel to lie to or to anchor. A decision showing that in a crowded harbor the existing circumstances vary the general rule was handed down by Justice Denman in the Circuit Court of Appeals, in the case of **Eureak—Ernest H. Meyer**, 1936 A.M.C., 1179 which dealt with a collision in San Francisco Bay the court stated that in determining the speed of each vessel

with reference to visibility in such a fog in a crowded harbor each is entitled to no more than half the area of visibility in which to stop.

Speed in a fog is applicable to sailing vessels as well as to steamers. If necessary to comply with the Rules a sailing vessel must make no more speed than is necessary to keep control of the vessel. If it be necessary to reduce the canvas carried in order to reduce the speed, she must do it.

The second paragraph of Article 16 has been, like the first paragraph of the Article, a source of many decisions in our courts.

The vagaries of sound in a fog are well known to seamen. Sounds which seem to be from a distant whistle may be from one close by and the reverse may be equally true. Also the direction cannot be accurately judged.

The sound of a whistle in a fog heard by several observers at the same time may appear to them to come from several points of the compass. But the rule is that if there is any doubt, the doubt must be resolved in favor of the possibility that the signal comes from forward of the beam.

In the **Eastern Knight—S. M. Spalding**, 18 F. 25 1020, the court held: "The *Eastern Knight* had clearly heard the *Spalding's* whistle, and although she believed it to be abaft the beam, she recognized it as coming closer, and as bearing more on the beam. She should have appreciated the notorious fact that the direction from which a sound seems to come through a dense fog is not to be implicitly relied upon. Prudence demanded that if the *Eastern Knight* should continue to go forward, she should not do so with any greater speed than was required to keep herself under control."

In the **Conner—Esperanza**, 16 Fed. 2d. 945, the court held in part as follows: "Where the warning was received or the commander thought that he heard a whistle forward of his beam, that is enough notice of the proximity of a vessel forward of his beam to cause him to comply with the rule. And even where a vessel is proceeding at half speed, the obligation to stop is none the less imperative."

In a case decided in January, 1928, by the Federal district court, **The Conehatte** *v.* **The Lubrafol**, the court held: "Navigation of a ship in a dense fog upon the assumption that another vessel whose signals are heard is proceeding upon a parallel course must always be unsafe unless it clearly appears that she has passed astern and her signals are receding in the distance. The only exchange of signals permissible, until vessels are in sight of one another, do not in any way indicate how the vessel may be heading with relation to each other, or whether their courses cross, converge, or are parallel. The direction of sound is notoriously confusing in a fog. . . ."

In the case of the **City of New York**, 147 U. S. 73, the court held: "There is no such certainty of the exact position of a horn blown in a fog as will justify a steamer in speculating upon the probability of avoiding it by a change of the helm, without taking the additional precaution of stopping until its location is definitely ascertained."

While it would seem that the Norwegian delegate to the Convention of 1889 had an unusual experience, a part of his statement before the Conference is quoted:

Mr. Flood ". . . Sometimes in a heavy fog you can hardly hear the whistle. I have seen, when the fog partly lifted, the steam come up from the steam whistle on the port side, and I have heard the sound come up on the starboard side. . . . Every practical seaman will agree with me that when he has expected to find a fog-signal on the starboard quarter he has often found it on the port quarter."

When in a fog a steam vessel must stop her engines upon hearing a fog signal apparently forward of her beam. The rule is imperative. It does not, however, say that the vessel must necessarily be brought to a dead stop. If the circumstances demand it, then she shall come to a dead stop, because cautious navigation required by the article would so demand. However, it must be remembered that a ship with no way on cannot maneuver whereas one with slight way on will answer her rudder.

The rule requires that the vessel be navigated with caution, if the position of the signal be not ascertained. It is not sufficient that the position be generally known. It must be accurately known before the vessel hearing it may do other than stop her engines and navigate with caution.

The times when the circumstances of the case would not permit the stopping of the engines are rare. Such a case would be when to stop the engines would invite the danger of being swept ashore by a strong current or being rammed by a tow.

After stopping the engines any further progress must be marked by cautious navigation. The Federal and Supreme Courts have held as follows:

"That it is imperative for a ship hearing forward of the beam the fog signal of another to stop her engines and thereafter proceed with caution."

In the case of the **Tillicum**, 230 Fed. 415, the court said: ". . . when the *Rosalie* first heard the whistle ahead her engines were stopped for about a minute, during which time she drifted, and hearing no response to the whistle she gave, was started forward again, but her engines were almost immediately reversed—she having heard another whistle, followed by a danger signal from the *Tillicum*. In the dense fog then prevailing, the *Rosalie*,

STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. **If the bearing does not appreciably change,** such risk should be deemed to exist.

in our opinion, cannot be regarded as having been navigated with caution in being started ahead so quickly without ascertaining anything in regard to the location of the vessel whose whistle she had heard and therefore violated the express provisions of the statute quoted."

It will be seen from the decision quoted that it is not sufficient to stop the engines momentarily and then proceed.

It is well to remember that it is quite possible for two vessels to synchronize their whistle signals so that one may be unable to hear the other. When a whistle signal abruptly ceases to be heard the interval of sounding one's own signal should be slightly changed, but in no case to exceed the legal interval, to make sure that the timing of the signals is not the reason for the failure to hear the other vessel's signal.

The rule does not mention the course to be steered after the engines are stopped, but the courts have ruled that there shall be no change in course until the position of each has been ascertained.

The district court in the case of the **Luella** *v.* **Rosedale** held in part: ". . . The *Luella* was also wrong in changing her course after hearing the *Rosedale's* fog signals before the position of the *Rosedale* was ascertained. . . ."

An exceptional situation arises when a number of men-of-war are cruising together in formation in a fog. It may reasonably be contended that a somewhat higher speed is necessary for the safe control of a squadron under these conditions than for that of a single ship, and *such speed as can be shown to be actually necessary for safety* is manifestly justified by the phrase in Art. 16, "having careful regard to the existing circumstances and conditions."

The obligation of each ship to keep clear of her neighbors in the squadron is at least as great as the obligation to keep clear of strangers, and anything which can be shown to be *necessary* for this can be justified without placing undue emphasis upon the military features of the situation.

STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearings of an approaching vessel. **If the bearing does not appreciably change,** such risk should be deemed to exist.

Art. 17. When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, viz.:

(*a*) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

(*b*) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(*c*) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(*d*) When both are running free, with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

(*e*) A vessel which has the wind aft shall keep out of the way of the other vessel.

Upon sighting an approaching vessel it should be the first thought of the officer-of-the-deck to get a bearing. By doing so he can readily determine whether or not there is risk of collision. Should there be such risk then he must take such action as is demanded under the rules of the road.

Art. 17. When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, namely:

(*a*) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

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(*c*) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(*d*) When both are running free, with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

(*e*) A vessel which has the wind aft shall keep out of the way of the other vessel.

Article 17 covers all cases where two sailing vessels are in danger of collision, except where the sailing vessel is an overtaking vessel, the situation is covered by Article 24.

In obeying this article the direction of the true wind, not the apparent wind, fixes the respective obligations of sailing vessels.

There are a few additional rules used by yachtsmen in racing, but they are not necessary to avoid collision. They may be found in any of the numerous publications dealing with yachting.

The duties of the privileged vessel and the burdened vessel are not set forth in this article, but Articles 21 and 22 apply to sailing vessels, as well as steam vessels. The sailing vessel having the right of way is to maintain her course and speed and the other to keep clear.

Although making no way through the water, a sailing vessel hove to shall act in accordance with the tack she is on and is considered close-hauled.

Steam-vessels Meeting.

Art. 18. When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This article only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end on, or nearly end on, to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own; and, by night, to cases in which each vessel is in such a position as to see both the side lights of the other.

It does not apply, by day, to cases in which a vessel sees another ahead crossing her own course; or by night, to cases where the red light of the one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

Steam-vessels Meeting, Passing, or Overtaking.

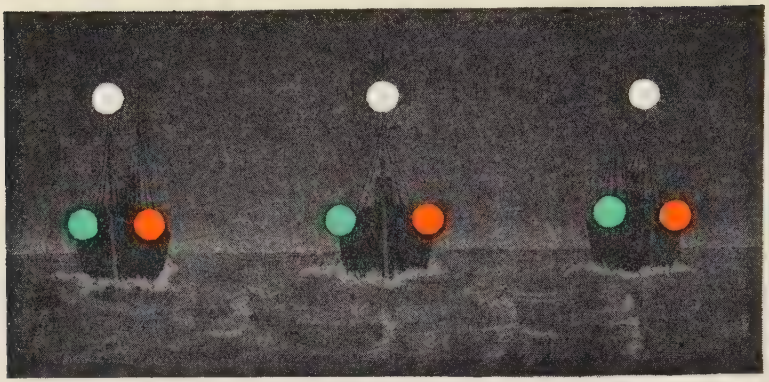
Art. 18—Rule I. When steam vessels are approaching each other *head and head,* that is, end on, or nearly so, it shall be the duty of each to pass on the port side of the other; and either vessel shall give, as a signal of her intention, one short and distinct blast of her whistle, which the other vessel shall answer promptly by a similar blast of her whistle, and thereupon such vessels shall pass on the port side of each other. But if the courses of such vessels are so far on the starboard of each other as not to be considered as meeting head and head, either vessel shall immediately give two short and distinct blasts of her whistle, which the other vessel shall answer promptly by two similar blasts of her whistle, and they shall pass on the starboard side of each other.

The foregoing only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own, and by night to cases in which each vessel is in such a position as to see both the sidelights of the other.

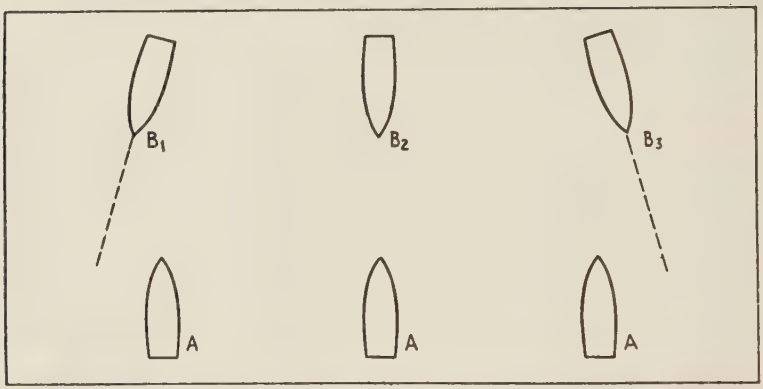
It does not apply by day to cases in which a vessel sees another ahead crossing her own course, or by night to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

Rule III. If, when steam vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving several short and rapid blasts, not less than four, of the steam whistle.

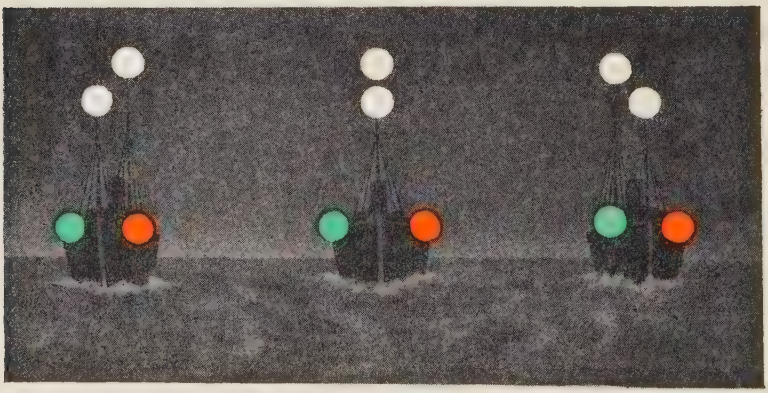
Rule V. Whenever a steam vessel is nearing a short bend or curve in the channel, where, from the height of the banks or other cause, a steam vessel approaching from the opposite direction cannot be seen for a distance of half a mile, such steam vessel, when she shall have arrived within half a mile of such curve or bend, shall give a signal by one long blast of the steam whistle, which signal shall be answered by a similar blast given



No Range Lights.



Showing "B" as Seen by "A".



Range Lights.

STEAMERS MEETING.

by any approaching steam vessel that may be within hearing. Should such signal be so answered by a steam vessel upon the farther side of such bend, then the usual signals for meeting and passing shall immediately be given and answered; but, if the first alarm signal of such vessel be not answered, she is to consider the channel clear and govern herself accordingly.

When steam vessels are moved from their docks or berths, and other boats are liable to pass from any direction toward them, they shall give the same signal as in the case of vessels meeting at a bend, but immediately after clearing the berths so as to be fully in sight they shall be governed by the steering and sailing rules.

Rule VIII. When steam vessels are running in the same direction, and the vessel which is astern shall desire to pass on the right or starboard hand of the vessel ahead, she shall give one short blast of the steam whistle, as a signal of such desire, and if the vessel ahead answers with one blast, she shall direct her course to starboard; or if she shall desire to pass on the left or port side of the vessel ahead, she shall give two short blasts of the steam whistle as a signal of such desire, and if the vessel ahead answers with two blasts, shall direct her course to port; or if the vessel ahead does not think it safe for the vessel astern to attempt to pass at that point, she shall immediately signify the same by giving several short and rapid blasts of the steam whistle, not less than four, and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as they have reached a point where it can be safely done, when said vessel ahead shall signify her willingness by blowing the proper signals. The vessel ahead shall in no case attempt to cross the bow or crowd upon the course of the passing vessel.

Rule IX. The whistle signals provided in the rules under this article, for steam vessels meeting, passing, or overtaking, are never to be used except when steamers are in sight of each other, and the course and position of each can be determined in the daytime by a sight of the vessel itself, or by night by seeing its signal lights. In fog, mist, falling snow or heavy rain storms, when vessels cannot see each other, fog signals only must be given.

Supplementary Regulations.

Sec. 2. That the Board of Supervising Inspectors of Steam Vessels shall establish such rules to be observed by steam vessels in passing each other and as to the lights to be carried by ferry-boats and by barges and canal boats when in tow of steam vessels, not inconsistent with the provisions of this act, as they from time to time may deem necessary for safety, which rules when approved by the Secretary of Commerce are hereby declared special rules duly made by local authority, as provided for in article thirty of chapter eight hundred and two of the laws of eighteen hundred and ninety. Two printed copies of such rules shall be furnished to such ferryboats and steam vessels, which rules shall be kept posted up in conspicuous places in such vessels.

Article 18 of the International Rule and Rule I of Article 18 of the Inland Rules are known as the "Passing Rule." The International Rule and Inland Rule are identical in meaning for steamers meeting end on or nearly so. The Inland Rules have attempted to clarify the meaning of the article but it is doubtful that they have succeeded. Both rules have the same requirements for vessels meeting end on or nearly so—they must change course to starboard and pass port to port.

Both rules describe what is not an end on meeting and the Inland Rules proceed to tell what shall be done in case the vessels are on approximately opposite course but so far on the starboard hand of each other as not to be meeting head and head. In this case they shall pass starboard to starboard.

If it be an actual head and head meeting, both rules require that the vessels shall change course to starboard and pass port to port.

Article 28 of the International Rules and Article 18 of the Inland Rules set forth the whistle signals to be used in a passing situation.

> Again, the Supreme Court, in the case of **The America**, 92 U. S. 432, held: "Steamships meeting end on, or nearly end on, should seasonably adopt the required precaution, and neither can be excused from responsibility, in case of omission, merely upon the ground that it was the duty of the other to have adopted the corresponding precaution at the same time, if it appears that the party setting up that excuse enjoyed equal facility to obey the requirement with the other party, and might have prevented the disaster. Imperative obligation is imposed upon each to comply with the rule of navigation; nor will the neglect of one excuse the other in a case where each might have prevented the disaster, as the law requires both to adopt every necessary precaution, if practicable, to prevent the collision, and will not tolerate any attempt of either, in such an emergency, to apportion the required

precaution to avoid the impending danger, in case where both or either might secure perfect safety to both ships and all entrusted with their control and management."

The range light permitted by Article 2 of the International Rules will eliminate the cause of collisions brought about by the situation when two ships are meeting nearly head and head and one vessel decides that the Rule for a head and head meeting applies while the other vessel assumes that they are sufficiently on the bow of each other that the rule does not apply.

This situation is well described in the words of Dr. Sieveking, a delegate from Germany to the Convention of 1889. Dr. Sieveking:

". . . You know that there are situations in which vessels may be in doubt whether they are crossing vessels or whether they are meeting nearly end on. The distance gradually widens, of course, where both lights are seen. Within this arc a vessel may find herself meeting another vessel when it cannot be known whether the other vessel is seeing both of her lights or not. A vessel sees, a little on her starboard bow, the green light of another vessel, and the green light only a very few points—or only a half point more or less, perhaps—on her starboard bow. She takes this vessel to be a vessel which does not see both her lights and therefore, in order to pass quite clear of her, she starboards (left rudder) a little. The other vessel, finding herself within this arc, sees both of the lights of the approaching vessel and thinks that the vessel is seeing both of her lights also, and that they are meeting vessels, and she ports her helm (right rudder.) This is a very frequent cause of collisions, as is known to everyone here."

The following discussion of Article 18 applies only to Inland Rules as under the International Rules there are no articles which parallel Rules III, V, and VIII of the Inland Rules.

Rule III specifies what is known as the "danger signal" or "alarm signal." It must be sounded immediately, whenever vessels are approaching and one fails to understand the course or intention of the other or in the case of an overtaken vessel which objects to a proposed passing. It is required even though the two vessels may not see each other due to some intervening ship or object.

In **The West Hartland**, 2 Fed. (2d) 834, the court held: "The excuse offered is that one of the navigators mistook the lights and the other misjudged the distance. There was culpable negligence . . .

"When there is doubt as to a vessel's course it is the plain duty of a navigator to solve that doubt in favor of safety by giving a danger signal or taking timely steps to avoid a collision before plunging his vessel into a position where a collision would be the natural, if not the necessary, consequence."

Pilot Rule VII is quoted here because it is closely related to Rule III of the Inland Rules.

Pilot Rule VII.

When two steam vessels are approaching each other at right angles or obliquely so as to involve risk of collision, other than when one steam vessel is overtaking another, the steam vessel which has the other on her port side shall hold her course and speed, and the steam vessel which has the other on her own starboard side shall keep out of the way of the other by directing her course to starboard so as to cross the stern of the other steam vessel, or, if necessary to do so, slacken her speed or stop or reverse.

If from any cause the conditions covered by this situation are such as to prevent immediate compliance with each other's signals, the misunderstanding or objection shall be at once made apparent by blowing the danger signal, and both steam vessels shall be stopped and backed if necessary, until signals for passing with safety are made and understood.

In connection with Pilot Rule VII the question arises as to whether or not the requirement that both vessels stop and back if necessary, conflicts with Article 21 of the Inland Rules. Article 21 requires the privileged vessel to maintain course and speed and were the words "if necessary" omitted from the Pilot Rule it would obviously be in conflict with the Inland Rules and therefore illegal. Under Articles 27 and 29 to be discussed later, the courts have frequently decided that both vessels must stop. If the Pilot Rule be considered in connection with those articles there would seem to be no conflict between Article 21 of the Inland Rules and Pilot Rule VII. (See page 439.)

Rule V is the first mention in the Rules of a long blast. The term is not used in the International Rules. A long blast is nowhere defined, but by practice it is a blast longer than a prolonged blast, a blast of ten or twelve seconds duration.

This rule is an exception to the general rule that whistle signals for meeting and passing vessels shall be sounded only when in sight of each other.

When vessels are moving from their berth they shall sound one long blast. The exact wording of the rule governing vessels leaving a slip has been somewhat altered by decisions of the courts. The courts have ruled that the ordinary steering and sailing rules shall not govern until the vessel is actually on her course. This places the operation of the vessel leaving the slip and others in the vicinity under Article 27, the General Prudential Rule and Article 29, The Rule of Precaution.

> **The Transfer No. 17** (254 Fed. 673): ". . . A vessel coming out of her slip and maneuvering to get on her course is not navigating upon any course, and the steering and sailing rules do not apply. . . . It was the duty of each of these vessels to act with prudence . . ." **The William A. Jamison**, 241 Fed. 950. **The Washington,** 241 Fed. 952. **The Newark,** 289 Fed. 801.

Two Steam-vessels Crossing.

Art. 19. When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

Steam-vessels Shall Keep Out of the Way of Sailing-vessels.

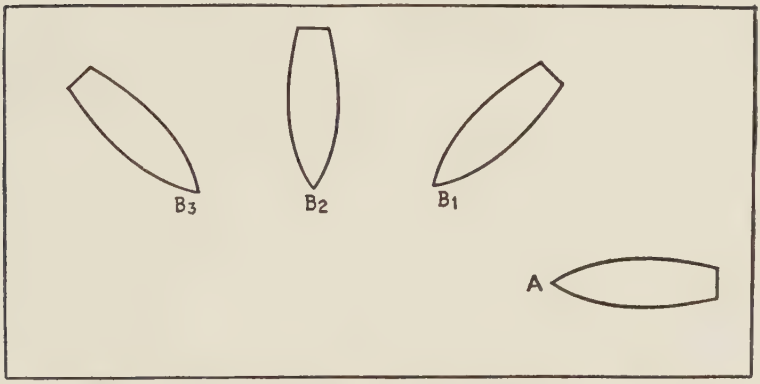
Art. 20. When a steam vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel.

Course and Speed.

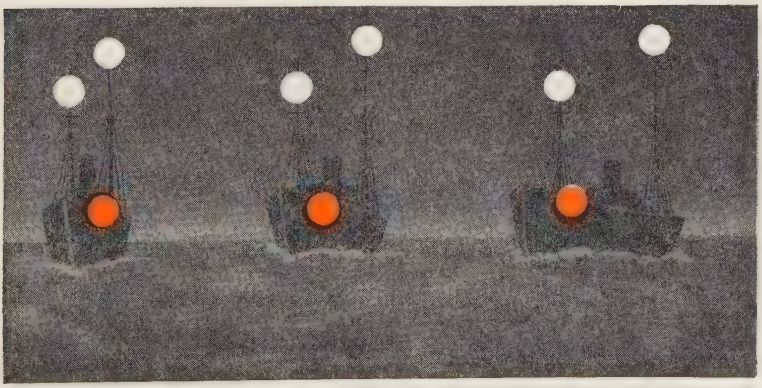
Art. 21. Where by any of these Rules one of two vessels is to keep out of the way, **the other shall keep her course and speed.**

Note.—When, in consequence of thick weather or other causes, such vessel finds herself so close that collision cannot be avoided by the action of the giving-away vessel, she also shall take such action as will best aid to avert collision. (*See Articles 27 and 29.*)

INTERNATIONAL.
No Range Lights.



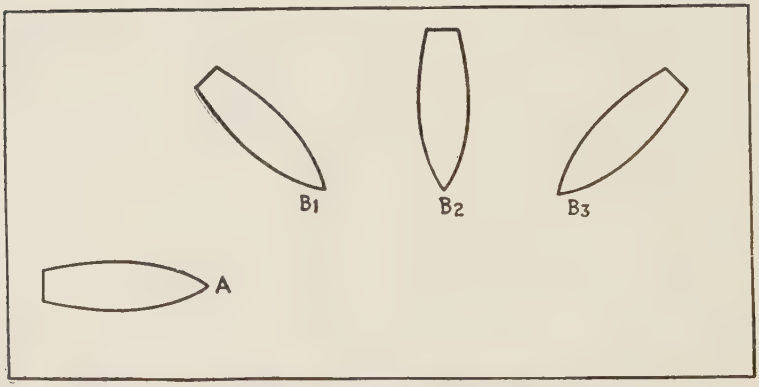
Crossing: "A" Sights "B" to Starboard.



INTERNATIONAL AND INLAND
Range Lights.

STEAMERS CROSSING WITH AND WITHOUT RANGE LIGHTS

INTERNATIONAL
No Range Lights.



Crossing: "A" Sights "B" to Port.

INTERNATIONAL AND INLAND
Range Lights.

STEAMERS CROSSING WITH AND WITHOUT RANGE LIGHTS

Two Steam-vessels Crossing.

Art. 19. When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

Article 19 states the rule in a crossing situation and applies only in such situation. The vessel, having to keep out of the way of the other, is known as the "burdened vessel"—the other, as the "privileged vessel."

Article 19 does not generally apply in narrow channels where vessels are rounding a bend and are momentarily on crossing courses. Such a situation would be governed by Article 25. However, in narrow channels where the situation is definitely that of crossing, Article 19 holds.

The signal to be used by vessels in crossing situations are discussed under Article 28.

Steam-vessels Shall Keep Out of the Way of Sailing-vessels.

Art. 20. When a steam vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel.

In cases involving risk of collision between sailing vessels and steam vessels, the sailing vessel is the "privileged vessel," except when she is overtaking the steamer. In the latter case she is the "burdened vessel" under Article 24.

The sailing vessel, being the "privileged vessel" must hold her course and speed under Article 21.

Further discussion of the relationship between sailing vessels and steamers will be found under Articles 21, 22, 23 and 24.

Course and Speed.

Art. 21. **Where, by any of these rules, one of the two vessels is to keep out of the way, the other shall keep her course and speed.**

(*See articles 27 and 29.*)

The "privileged vessel" is by Article 21 required to hold her course and speed, but this does not mean her exact compass course nor does it mean her exact speed in knots. This will be seen from the quoted decisions of the courts.

Liverpool, Brazil & River Platte Steam Navigation Co. *v.* **United States**, 12 Fed. (2d) 128, decided January, 1926: "The course referred to in the International Regulations is the actual

course and not the compass direction of the heading of the vessel at the time the other is sighted. The true interpretation of the term in the rule (art. 18*) 'keeping her course' (is that the ship) is at liberty to hold upon the course which she would have pursued had no vessel been in sight, and was not bound to follow the direction in which her head, as she rounded the point, happened to be at the moment she was first sighted."

"The *Romney* was not under any obligation to change her helm and lay a straight course. It was the duty of the *Manassas* to take notice of the character of the *Romney's* course. The captain and others on board the *Manassas,* observing that the *Romney* was not proceeding on a straight course, but was maintaining a curved course to starboard, made no effort to keep out of the way, or to avoid the collision or the risk of collision. Instead of stopping, reducing speed, reversing, or going to starboard in time to avoid the collision, the *Manassas* did the most dangerous thing possible by attempting to cross the *Romney's* bows, notwithstanding that the signals were crossed, and that the *Romney* refused to give assent to any maneuver not complying with the regulations."

In the case of the **Port Phillip** and the **Proteus**, the district court held in part as follows: "When the *Port Phillip* did come out she was the privileged vessel. It was a crossing case. The effort to make it one of special circumstances depends upon the assertion that the *Port Phillip* was not on a steady course. It involves a misconception of the meaning of that phrase. The ship is on a steady course not only when her heading does not change, but whenever her future positions are certainly ascertained from her present positions and movements.

"A steady course may thus involve many changes of heading. It is enough if these can, with accuracy, be foretold. Whether the way be sinuous or the speed variable it makes no difference so long as it be plainly discernible. She is on a course and if that course crosses the course of another vessel who holds her on her starboard hand, the latter must keep out of her way. Now it is well settled that this applies to head-on cases in a winding channel . . . (**Victory**, 168 U. S. 410; **Arrow**, 214 Fed. 743.) . . ."

In **Napoli**, 12 Fed. 2d 130: "I regard this as a case of crossing courses and the tug as the yielding vessel. It is true that the *Napoli* was not preceeding with a constant speed, but she was on a steady course, and her speed was as nearly constant as her purposes and destination permitted. It is not uncommon with large vessels similarly situated to hold a very slow speed in precisely this way, starting under one bell, stopping till the momentum has partly run off, and then starting again. This does result in a

*Present Article 21.

varying speed; but, the navigation being usual, other masters are chargeable with observing and knowing it, and have the means of learning what the positions of a ship so proceeding will be at future moments, which is the presupposition in which the crossing rule applies.

"The only remaining question is of the *Napoli's* fault as holding-on vessel. The two faults are asserted against her: First, failing to keep her speed; second, failing to back when it became evident that the tug would not clear. The rule which requires a holding-on vessel to keep her speed does not, however, mean that she must change the speed, as already disclosed. It means just the opposite—i.e., that she must not change what she is doing because of the approach of the yielding vessel. The whole theory is that the yielding vessel shall be able to rely in her navigation upon what the holding-on vessel will do. This requires that the holding-on vessel shall act just as she has been acting, and if she has been going with a varied speed that she shall keep varying that speed as before.

"It appears to me that the same analogy applies as in cases where the apparent course of the holding-on vessel is not straight. There it is held that in 'holding her course' she must follow the usual changes of direction which her apparent course involves (*Velocity,* L. R. 3, P. C. 44; *Esk,* L. R. 3, P. C. 436) and should not lay a straight compass course after the vessels sight each other. So, I think that 'keeping her speed' means keeping the apparent variation of speed, not changing it to a constant velocity. That would be only deceptive.

". . . The *Napoli* was not inattentive and appears to have held on until in her judgment she must act. In such circumstances it is not usual to revise the judgment of the master as to the point where collision was unavoidable . . ."

The rule is the same in England. It has been applied as well to a crossing case where the privileged vessel was held without fault though she stopped to take on a pilot.

The duties of the privileged vessel to hold course and speed are imposed upon a sailing vessel when privileged as well as upon a steam vessel. The interpretation of the rule for sailing vessels is comparable to that for steamers. A privileged sailing vessel which was headed for shoal water could not be expected to maintain her course to a point where she would be in danger of grounding. It is presumed that the other vessel is aware of the shoal water and will take such action as will be necessary to avoid the risk of collision should the sailing vessel tack.

No departure from the rule for the privileged vessel to hold course and speed is permissible except under Articles 27 and 29.

The Straits of Dover, 120 Fed. 900: "The privileged vessel should have kept her course and speed unless in case of immi-

nent danger, and the *Bluefields* (burden vessel) had the right to assume that she would do so, and in case of emergency justifying a departure therefrom, should have followed strictly the rule (art. 28, sounding the proper signals) governing such maneuver, which she failed to do."

In the **Potomac**, 8 Wall. 590, the Supreme Court held: "One of these rules requires the steamer to keep out of the way of the sailing vessel; but to enable her to do this effectively, the law imposes the corresponding obligation on the sailing vessel to keep her course. If, therefore, the steamer adopts proper measures of precaution to avoid the collision, which would have been effective if the schooner had not changed her course, she is not chargeable for the consequences of the collision."

A departure from the rules on the part of the privileged vessel as a matter of courtesy or assistance to the burdened vessel is not permissible. Should a collision result following such action it is safe to say that the courts would attach blame to the privileged vessel.

It is quite possible that an existing situation may involve three ships. In this case a ship may be burdened in relation to one ship and privileged in regard to another ship. Let us call them A, B, and C. Steamer A is the burdened vessel between A and B but A is the privileged vessel between A and C. In this case any action A may take in accordance with the rules to avoid B should be anticipated by C and A in taking such action is maintaining her course and speed within the meaning of the rules.

In **Norfolk**, 1924 A.M.C. 886, 297 Fed. 251, Judge Soper said: "It may be admitted that a change of speed is sometimes rendered necessary by the presence of a third vessel, for which provision must be made. In such cases the giving-way vessel has knowledge, or should have knowledge, of the presumable course and speed of the holding-on vessel, and must govern her actions accordingly . . ."

One of the most trying positions in which an officer can find himself is that of holding on with prospect of collision where the other vessel ought to keep clear but takes no action to do so. The impossibility of knowing whether the giving-way ship intends to act, and if so when, and the necessity of deciding when the time has come which will justify the holding-on ship acting under Articles 27 and 29 make the situation very difficult.

The use of a flare-up or detonating signal in accordance with Article 12 of the International Rules or Rule III of Article 18 of the Inland Rules should prove helpful in this situation.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

Steam-vessels Shall Slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel, shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

The circumstances that make it unavoidable or permissible for the burdened vessel to cross ahead of the privileged vessel are rare.

If the one, having the other on her own starboard hand, can pass well clear ahead, then there is no risk of collision and the rule does not apply. Such a case would be when the bearing of a vessel sighted in the distance by the burdened vessel, draws aft rapidly. If the circumstances are such that the burdened vessel cannot avoid danger by stopping, backing or going astern of the privileged vessel, the circumstances of the case do not permit crossing astern.

Any departure from the rule to avoid crossing ahead would have to be justified under Article 29. It may be done legally only when unable to avoid collision by going astern, stopping or backing.

Steam-vessels Shall Slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel, shall, on approaching her, if necessary, slacken her speed or stop or reverse.

This rule sets forth another duty of the burdened vessel. If necessary to avoid collision or to avoid crossing ahead, she must slacken her speed, or stop, or reverse.

Articles 19, 20, 21, 22 and 23 are so closely related that Court decisions involving the duties of privileged and burdened vessels frequently involve more than one of the rules. Several points involving the rules may be stressed by referring to court decisions. When a steam-vessel and a sailing vessel are approaching so as to involve the risk of collision, the courts have insisted upon extraordinary care on the part of the steamer.

> The **Job H. Jackson**, 144 Fed. 896: "The rule required the steamer to do more than merely to so shape its course as to pass the schooner without striking her. Its duty was to give the schooner a berth wide enough to allow a sufficient margin for safety, taking into account the contingencies of navigation . . . (the steamer) under the circumstances presented, failed to give the schooner the wide berth demanded, allowing insufficient margin of safety to meet the contingencies of navigation which should have been anticipated. (**Bonnah et al.** *v.* **Lakeside S.S. Co.,** 221 Fed. 40.)
>
> "Close and diligent observation of the course and movements of a sailing vessel is required.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these Rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

Every vessel coming up with another vessel from any direction more than two points abaft her beam, i.e., in such a position, with reference to the vessel which she is overtaking, that at night she would be unable to see either of that vessel's side lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these Rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel cannot always know with certainty whether she is forward or abaft this direction from the other vessel, she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

"The established rule is: 'That the steamship, from the moment the sailing vessel is seen, shall watch with the highest diligence her course and movements, so as to be able to adopt such timely measures of precautions which will necessarily prevent the two boats coming in contact.'"

It is not sufficient that the burdened vessel wait until danger of collision is imminent before taking such action as will clear the privileged vessel. Her action must be prompt and so designed as to give a clear indication of her intentions.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these Rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at at night she would be unable to see either of that vessel's side lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel cannot always know with certainty whether she is forward or abaft this direction from the other vessel, she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

Rule VIII of Article 18 of the Inland Rules must be considered in connection with Article 24. Reference to the rule is necessary to determine the whistle signals to be used in an overtaking situation under the Inland Rules.

The International Rules and Inland Rules for overtaking vessels differ radically in one respect. Under the Inland Rules the overtaking vessel must receive the assent of the overtaken vessel before she may pass. This is required under Rule VIII of Article 18. Under International Rules no whistle signals need be sounded by the overtaking vessel unless she has to change course to pass the overtaken vessel or unless required by the ordinary practice of seamen under Article 29.

The overtaking vessel must not pass so close to the overtaken vessel as to cause danger of collision by suction or to hamper the overtaken vessel should it be necessary for her to change her course. The status of the

overtaking vessel does not change until she is well past and clear and until that time she is definitely the burdened vessel. She may not, after passing the beam of the overtaken vessel, change course and thereby change an overtaking situation into a crossing situation so as to place the burden of keeping clear on the vessel she has overtaken.

"**King-Noronic**," 1931 A.M.C., 1001, 49 Fed. (2), which grew out of a collision in Duluth Harbor, the court held: "That suction of an overtaking vessel is frequent causes of collision, especially if she is larger than the overtaken vessel and the channel is narrow, is well known, **Mesaba**, III Fed. 215; **Aureole**, 113 Fed. 224; **North Star**, supra (132 Fed. 145); **Robert Fulton**, 10 F. (2d) 424, 1926 A.M.C. 845. An overtaking vessel takes whatever risk attends her attempt to pass from whatever cause arising, except from the fault of the vessel ahead (**Mesaba**, supra), and the burden was upon *Noronic* as the overtaking vessel to show that the injury to the *King* was occasioned by no fault on her part but by some fault or neglect of duty on the part of the *King*."

The Industry, 29 Fed. 29: "The fault of the *Industry* is so plain and so gross that the only question can be as to whether the *Vilsing*, the vessel ahead, was not also at fault for her change of course. Article 24 puts the burden upon the overtaking vessel to keep out of the way until she is 'past and clear.'

"If she would pass, an overtaking steamer must signal before passing, and must get the consent of the steamer ahead. The rule concludes by saying that the steamer ahead shall in no case attempt to cross the bows of the overtaking steamer or to crowd upon her course. It is perhaps possible to read this language as referring to the period before the exchange of signals, as well as thereafter, but it seems to us unreasonable to do so. Rather we think it intended to make clear that it is only after the exchange of signals that the duty of the vessel ahead begins at all.

"The rules provide no signal by which the overtaken vessel may declare her purpose to change her course and speed, and, if she is bound to keep both, she is, as it were, frozen in her navigation from the moment that the risk of collision begins, merely because the overtaking vessel begins to overhaul her, something which is not always easy to ascertain. It is, therefore, fair to suppose that her consent is required, not alone because she may think passing dangerous in any case, but also because she may need to change her course for her own purposes to which the interests of the overtaking vessel can hardly be considered equal. The latter should, therefore, be obliged to hold herself in check against unexpected changes of course, and be prepared to meet them. The Supreme Court, in the **Great Republic**, 23 Wall. 20, decided in accordance with the construction we have adopted, has

never qualified its ruling. In that case a vessel ahead was held blameless, which starboarded across the bows of the overtaking vessel coming upon her port quarter. The overtaking vessel was held at fault for not keeping enough distance to allow for such an unexpected change of course."

The court here referred to the following cases: **Merrell C. Hart**, 188 Fed. 49; **M. T. Rudolph**, 292 Fed. 740; **The Georgia**, 18 F. (2d) 743; **Lizzie M. Walker**, 3 F. (2d) 921.

M. T. Rudolph, 292 Fed. 740. In this case both vessels were headed in the same direction. The tug was two hundred feet on the port bow of the *Rudolph*. There was no exchange of signals for passing or change of course. The tug changed course to the right and headed right across the *Rudolph's* bow. A collision resulted. The *Rudolph* was the overtaking vessel. The court in its decision held as follows: "As the *Rudolph* was the overtaking vessel by the admission of her own captain, and at no time prior to collision was ever 'finally past and clear' of the *Roche,* it was the duty of the *Rudolph* to keep out of the way of the *Roche,* and this she most clearly did not do. That she was in most serious fault is perfectly plain. The *Rudolph,* if she contemplated passing the *Roche,* as she evidently did, for her speed at the time was about six miles per hour, while the *Roche* was only making about one and one-half miles an hour, was ignoring also Rule 8 of Article 18 of the Inland Regulations, which provides:

"'When steam vessels are running in the same direction, and the vessel which is astern shall desire to pass on the right or starboard hand of the vessel ahead, she shall give one blast of the steam whistle as a signal of such desire, or, if the vessel ahead does not think it safe for the vessel astern to attempt to pass at that point, she shall immediately signify the same by giving several short rapid blasts of the steam whistle, not less than four, and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as they have reached a point where it can be safely done, when said vessel ahead shall signify her willingness by blowing the proper signals. The vessel ahead shall in no case attempt to cross the bow or crowd upon the course of the passing vessel.'"

Under Inland Rules, unless the overtaking vessel has sounded her signal she cannot be absolved from blame of collision on the basis that the overtaken vessel failed to keep a lookout aft. The responsibility for keeping clear is placed upon the overtaking vessel and she may not shift her responsibility to the overtaken vessel.

The **James L. Morgan**, 225 F. 34: "If the overtaking vessel comes so close to an overtaken vessel that a sudden change of course by the latter may bring about a collision, the fault is that

Narrow Channels.

Art. 25. In narrow channels every steam vessel shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such vessel.

of the overtaking vessel. She should not come so close without a signal. As this court held in the **Merrell C. Hart**, 183 Fed. 49, 'The overtaken vessel is not required to look behind before she changes her course, however abruptly.' . . ."

The **Albemarle**, 22 F. (2d) 840: "The master of an overtaken vessel, receiving no signal from the overtaking vessel, is not required to look astern before changing his course, however abruptly. The court feels that the master of the *Hamilton* was under no obligation to warn the *Brandywine* coming up behind her and which had not given him a signal herself.

"It was his clear duty to watch them continuously as he approached, because his was the burdened vessel. This being true, the master of the *Hamilton* being under no obligation to look astern, the *Brandywine* must be held to have been solely at fault."

A sailing vessel has the right of way over steam vessels except when the sailing vessel is an overtaking vessel. In the latter case, Article 24 applies in full to sailing vessels. It also applies between sailing vessels.

The **Buenos Aires**, 5 F. 20, 425: "A sailing vessel, except when it is the overtaking vessel, is always the privileged vessel as against a steamer, and it is her duty to hold her course and speed. (Art. 20, Int. Rules of the Road.) . . ."

When it is said that the overtaken vessel must hold her course and speed it is of course understood that it is the course and speed she would normally hold in completion of her maneuver and not the compass course and exact speed.

In a narrow channel it is best that the overtaking vessel pass to port of the overtaken vessel. Should another vessel be met head and head or nearly so, this gives the privileged vessel (the overtaken vessel) the opportunity to change to starboard without placing her across the bow of the overtaking steamer.

Narrow Channels.

Art. 25. In narrow channels every steam vessel shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such vessel.

The rule is mandatory and may not be violated in order to take advantage of a favorable current or deep water on the opposite side of the channel. When it becomes necessary for a vessel to deviate from the rule her change must be no more than necessary and she must return to her proper side as soon as possible. Such change may only be made because it is at the time not safe and practicable to do otherwise.

The Federal courts, in the case of **The Three Brothers**, 170 Fed. 48, held as follows: "The rule must be construed in the light of common sense. Its purpose is to prevent collisions, not to produce them. It is not an inflexible rule to be followed in all cases, and where it is manifest that blind adherence will produce disaster, it is not only the right but the duty of the navigator to disregard it. The rule so states explicitly: It must be followed only 'when it is safe and practicable.'"

In the case of **The Victory** and **The Plymothian**, 168 U. S. 410, the court held: "Each of these vessels was entitled to presume that the other would act lawfully; would keep to her own side; if temporarily crowded out of her course, would return to it as soon as possible; that she would pursue the customary track of vessels in the channel, regulating her action so as to avoid danger."

A custom or practice of vessels to use the wrong side of a narrow channel under certain tidal conditions has been held to be no excuse for violation of the rule.

Again the Federal courts have held in the case of **The Transfer No. 10**, 137 Fed. 666: "The rules in this case made it the duty for these transports to be on the right-hand side of the center of the stream, and, in point of fact, admittedly they were on the left. The fact that it may be the custom to do this when there is ebb tide, and that it may be easier to go up on the New York side than on the other side, and that they thereby can go a little faster, does not alter the fact that any vessel that goes up in that way violates the law and takes the risk, and, if there is any collision, is presumably in fault."

Yoshida-Maru-Charles R. McCormick. "The Rules of Navigation required the *Yoshida-Maru* to keep to the right side of the channel unless it was unsafe or impracticable for her to do so. (Art. 25.) In place of observing this rule, she sounded two blasts of her whistle when about a mile and a half from the *McCormick,* for the reason that she desired to obtain the consent of the *McCormick* to pass to the left because she wanted the deep waters on that side of the river. The whistle was repeated, the *McCormick* sounded one blast.

"The *Yoshida-Maru,* having violated the rules of navigation, the burden of proof is on her to justify her departure therefrom by showing that it was unsafe or impracticable for her to observe them.

"* * * The *McCormick* was not bound to agree to the proposed movement when she heard the two blasts, as the circumstances at that time did not require a departure from the ordinary rules."

Rights of Way of Fishing-vessels.

Art. 26. Sailing vessels under way shall keep out of the way of sailing vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fairway used by vessels other than fishing vessels or boats.

General Prudential Rule.

Art. 27. In obeying and construing these rules, due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

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Article 26 fails to state any relation between sailing fishing vessels and steamers or between steam vessels fishing and other steamers. The case of sailing vessels fishing and steamers is covered under Article 20, which requires steam vessels to keep clear of sailing vessels.

The relation of steamers to steam vessels fishing is not covered in the rules; however, the general rule is for all vessels to keep clear of vessels fishing. The English courts in the case of the steamer *Grovehurst* and a steam trawler, the *Europa,* decided that the *Grovehurst* should have kept clear. The purpose of fishing vessels carrying distinctive lights is to indicate the fact that their movements are hampered and it follows that unhampered vessels should keep clear.

General Prudential Rule.

Art. 27. In obeying and construing these rules, due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

Article 27 is referred to as the General Prudential Rule. It is often said that the Rules of the Road may not be violated until the time has arrived to act under the General Prudential Rule. Such a conception is not correct. True, when action is taken under Article 27, the steering and sailing rules need not apply, but action under Article 27 is then definitely required by the rules. Compliance with this rule is mandatory as in the case of all the other articles.

Situations requiring action under Article 27 are usually brought about by failure to follow strictly the prior rules, or to recognize promptly that risk of collision exists. However, when the situation develops into one of immediate danger the privileged vessel may not longer carry out the rules by maintaining her course and speed. She must take such action as will assist in avoiding the danger.

The General Prudential Rule may be invoked only when there is immediate danger of collision. Should the privileged vessel fail to hold course and speed before action was dictated by the imminent danger of the situation, she would be guilty of a violation of the rules.

When departing from the usual steering and sailing rules, the master of a vessel must be prepared to prove that danger of collision was so

Sound-signals for Vessels in Sight of One Another.

Art. 28. The words "short blast" used in this article shall mean a blast of about one second's duration.

When vessels are in sight of one another, a steam vessel under way, in taking any course authorized or required by these Rules, shall indicate that course by the following signals on her whistle or siren, viz.:

One short blast to mean, "I am directing my course to starboard."

Two short blasts to mean, "I am directing my course to port."

Three short blasts to mean, "My engines are going full speed astern."

imminent that action under those rules offered no chance of escaping collision and that his action was that action calculated best to avoid collision.

The **Alber Dumois**, 117 U. S. 240: "Exceptions to the general rules of navigation are admitted with reluctance on the part of the courts and only when an adherence to such rules must almost necessarily result in a collision—such, for instance, as a manifestly wrong maneuver on the part of the approaching vessel."

Yang-Tsze Insurance Association et al. *v.* **Furness Withy & Co.**, 215 Fed. 859: "The application of the Rule 27 is restricted by its terms to situations of immediate danger. That rule applies only to exceptional cases. As said by the Supreme Court, in the **Oregon**, 158 U. S. 186, exceptions to the rule are admitted with great caution and only when imperatively required by special circumstances of the case. It follows that, under all ordinary circumstances, a vessel discharges her full duty and obligation to another by a faithful and literal observation of these rules."

In the **New York**, 175 U. S. 187, 205: "Cases arise in navigation where a stubborn adherence to a general rule is a culpable fault, for the reason that every navigator ought to know the rules of navigation are ordained not to promote collisions."

The **Straits of Dover**, 120 Fed. 900: "The obligation imposed to obey these rules is imperative, and those violating them, except under circumstances contemplated by the rules, must bear the consequences if damage ensue."

Sound-signals for Vessels in Sight of One Another.

Art. 28. When vessels are in sight of one another a steam vessel under way whose engines are going at full speed astern shall indicate that fact by three short blasts on the whistle.

Pilot Rules.

Signals:

The whistle signals provided in these rules shall be sounded on an efficient whistle or siren sounded by steam or by some substitute for steam.

A short blast of the whistle shall mean a blast of about one second's duration.

A prolonged blast of the whistle shall mean a blast of from four to six seconds' duration.

One short blast of the whistle signifies intention to direct course to own starboard, except when two steam vessels are approaching each other at right angles or obliquely, when it signifies intention of steam vessel which is to starboard of the other to hold course and speed.

Two short blasts of the whistle signify intention to direct course to own port.

Three short blasts of the whistle shall mean, "My engines are going at full speed astern."

When vessels are in sight of one another a steam vessel under way whose engines are going full speed astern shall indicate that fact by three short blasts of the whistle.

Pilot Rule II.

Steam vessels are forbidden to use what has become technically known among pilots as *"Cross Signals,"* that is, answering one whistle with two and answering two whistles with one.

Pilot Rule II.

Article XVIII of the Inland Rules must be read in connection with Article 28 and the Pilot Rules in order to thoroughly understand the required whistle signals in Inland waters.

The International Rules define a short blast as a blast of about one second's duration, but the Inland Rules fail to prescribe its duration. This difference is, however, rectified by the Pilot Rules, which gives the same definition of a short blast as found in the International Rules.

The Inland Rules fail to specify the signals to be used in a crossing situation, but this is again set forth in the Pilot Rules.

The Sound-signals set forth in Article 28 of the International Rules and those set forth in Articles 18 and 28 of the Inland Rules, as well as the preliminary article of the Pilot Rules quoted, shall be sounded only when vessels are in sight of each other, except in the cases of a steamer nearing a bend, a steamer leaving a slip or the danger signal under the Inland Rules.

The International Marine Conference of 1889 spent many hours in the discussion of the use of sound-signals in a fog. There were numerous suggestions to at least permit, if not make compulsory, sound-signals, showing course and change of course in a fog. All were voted down and the only signals which may be sounded in a fog where vessels are not in sight of each other are those contained in Articles 9 and 15 of the International Rules.

Under the International Rules the whistle signals indicate a change which is in the process of accomplishment whereas under the Inland Rules

the whistle signals indicate intent or in the case of an overtaking vessel a desire to carry out a certain maneuver.

The Pilot Rules provide a signal for the privileged vessel in a crossing situation to show that she intends to hold her course and speed. No such signal is provided in the International Rules.

Under International, Inland and Pilot Rules, signals must be sounded in accordance with the law.

> In the **West Hartland**, 2 Fed. (2) 834, the court held: "After giving the signal that she would maintain her course and speed, the *West Hartland* was at fault in reversing her engines full speed astern without notice or warning."

> In the **A. A. Raven**, 231 Fed. 380, the court held: "She gave no signals whatever from the beginning to the end and therefore she cannot be absolved for such an omission."

The English Admiralty Courts have held that the rules requiring signals are obligatory.

Not only must the signals be sounded, but they must be sounded promptly. The sounding of signals while ships are yet well separated will go far towards eliminating danger of collision.

> In the **Comus** *v.* **Lake Frampton**, 19 Fed. (2d) 774, the court held: "That a ship is at fault for changing course two or three miles away from another ship without blowing a signal when in the position of crossing or meeting vessels. Also an unannounced change of course renders the one changing her course at fault."

An interesting and important point arises when one of two crossing vessels is going astern instead of ahead. It is the practice of seamen to consider such cases that the rules apply *with reference to the direction of motion* of the ship, so that for the time being, the starboard side becomes the port side and the port side the starboard side. This practice has been sanctioned by several decisions of the courts, and may be regarded as fully established. In other words, we must consider the pilot of a backing vessel to be facing aft, toward the direction in which his ship is moving. He must then keep clear of a vessel *on his right hand* as if that were his starboard side. And his whistle signals must correspond. Similarly, the vessel which is crossing him must regard the stern of the backing steamer as if it were the bow, etc.

Under International Rules an overtaking vessel need not obtain assent from the overtaken vessel, but she must sound the proper whistle signal, if she changes course to pass. Her responsibilities as an overtaking vessel are set forth under Article 24.

Under Inland Rules, Article 18, Rule VIII, an overtaking vessel shall not pass until she has received the assent of the overtaken vessel. The overtaken vessel must answer the signal of the overtaking vessel by giving assent or sounding the danger signal. If the overtaking vessel fails to

receive assent and a collision ensues, then there immediately exists a presumption of guilt on her part. Until such time as the overtaking vessel has received the assent of the overtaken vessel, the latter has no need to hold her course and speed. The overtaken vessel may refuse assent by sounding four short blasts. This refusal may be based on the belief that the maneuver is at the time dangerous or that the vessel ahead intends to change course.

If the overtaken vessel does not agree with the proposed signal, but is willing to be passed on the other side, she may answer the first signal with the danger signal and follow it with the signal for being overtaken on the other side. For example, the ship astern sounds one short blast, but the ship ahead intends soon to change course to starboard. The ship ahead sounds four blasts to show she does not assent to the proposed maneuver and then sounds two short blasts to show she is willing for the overtaking vessel to pass her on her port hand. The overtaking vessel may then answer with two short blasts and proceed to pass on the overtaken vessel's port hand.

Pilot Rule II Forbids "Cross Signals."

In crossing situations, there has seemed to be a conflict between Pilot Rules II and VII, and Inland Rules, Arts. 19, 21, 22 and 23. Art. 21, Inland Rules, imposes on the privileged vessel the duty to keep her course and speed, until collision is imminent (Art. 27), which has been interpreted as giving her the right to "cross" a two-blast signal from the burdened vessel with a one-blast signal.

This interpretation can no longer be held, as explained below.

The Supreme Court recently held that the Pilot Rules (i.e., II and VII) are not inconsistent with the Inland Rules.

Based on this decision, a court decision (El Isleo Case) pronounced the new interpretation which is briefly that the privileged vessel must not cross the signal of the other.

Now, in a crossing situation a privileged vessel faced with a two-blast signal from the burdened vessel, must assume only that it is a special circumstance, an emergency of some sort such as a strong tideway, a tow astern or in the way, or shoal water, which makes it necessary for the burdened vessel to pass ahead of the privileged vessel, and the privileged vessel can only choose between blowing a two-blast assent, or blowing the danger signal. In the latter case both vessels must be stopped or backed till the situation is cleared up.

> **The George S. Schultz,** 84 Fed. 508: "The burdened vessel is to keep out of the way. How it shall do so is not prescribed. It may, of course, turn to starboard sufficiently to allow the privileged vessel to pass, and then proceed under the stern of that vessel. This is the path of safety. It may keep out of the way by crossing the bows of the privileged vessel, but, in undertaking this maneuver, it is chargeable with the knowledge that the other vessel is by express rule required to keep her course. Unless, then, the burdened vessel has time and space thus to cross in safety without the help of the privileged vessel, prudent naviga-

tion would forbid her making such an attempt. If she made the attempt and thereby brings about the collision, she is at fault for not keeping out of the way of the privileged vessel. The inspector's rules give her the opportunity of agreeing with the privileged vessel that this usually risky maneuvering shall be attempted, and that the privileged vessel will cooperate to that end. Such agreement would constitute a special circumstance, within the meaning of Article 29. This agreement is affected when the burdened vessel's signal indicating an intention to cross in front of the privileged vessel is accepted by a corresponding signal from the privileged vessel. But the burdened vessel which without such agreement undertakes to navigate as if she had the privilege, and the other the burden, assumes all responsibility for the consequences resulting from such failure to conform to the regulations. All this has been explained in the opinions of the courts over and over again."

Summary of Sound Signals.

**** bell _____ prolonged blast _ short blast

SOUND SIGNALS FOR VESSELS IN SIGHT

Signal	International Rules	Inland or Pilot Rules
_	I am directing my course to starboard.	By an overtaking vessel: I desire to pass on your starboard hand. (Assent is required.) By the privileged vessel in a crossing situation: I intend to hold course and speed. In all other cases: I intend to change my course to starboard.
_ _	I am directing my course to port.	By an overtaking vessel: I desire to pass on your port hand. In all other cases: I intend to change my course to port. (Assent is required.)
_ _ _	My engines are backing full speed.	My engines are backing full speed.
_ _ _ _	.....	This is the danger signal and indicates: I do not understand your course or intentions. I object or can not immediately comply.

SOUND SIGNALS IN A FOG

All blasts to be sounded on the whistle or siren by steam vessels and on the fog horn by sailing vessels and vessels in tow.

Type of Vessel	International Rules		Inland or Pilot Rules	
	Signal	*Maximum Interval*	*Signal*	*Maximum Interval*
Steam vessel underway with way upon her...	———	2 minutes	———	1 minute
Steam vessel underway but stopped and having no way upon her..	——— ———	2 minutes	———	1 minute
Vessel towing.....	——— — —	2 minutes	——— — —	1 minute
Vessel being towed.....	——— — — Optional; for any vessel in tow	2 minutes	——— — — Optional; for any vessel in tow	1 minute
Vessel not under command.....	——— — —	2 minutes	———	1 minute
Vessel working with submarine cable.....	——— — —	2 minutes	———	1 minute
Vessel at anchor.....	****	1 minute	****	1 minute
Sailing vessels:				
On starboard tack....	— (Blast)	1 minute	— (Blast)	1 minute
On port tack	— — (2 Blasts)	1 minute	— — (2 Blasts)	1 minute
Wind abaft the beam...	— — — (3 Blasts)	1 minute	— — — (3 Blasts)	1 minute
Vessels fishing.....	— **** Blast	1 minute	Signal for vessel of her type	

Sound Signals for Vessels Not in Sight of Each Other

Steam vessel leaving her slip.....	.....	.....	Long blast	.....
Steam vessel within one-half mile of bend in river.....	.....	.....	Long blast	.....
Danger signal.....	.....	.....	— — — —	.....

No Vessel Under Any Circumstances to Neglect Proper Precautions.

Art. 29. Nothing in these Rules shall exonerate any vessel, or the owner, or master, or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Precaution.

Art. 29. Nothing in these Rules shall exonerate any vessel, or the owner, or master, or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

The number and location of lookouts required under Article 29 has been dealt with by the courts in many cases involving collision.

A lookout must be a competent man, instructed in his duties, who gives his entire time while on watch to being a lookout. He may not be assigned other duties which distract his attention from his duties as a lookout.

During the day, in clear weather, only one lookout is required. He must be competent and so stationed that he has an unobstructed view.

> The U. S. Navy Regulations state: He (The Captain shall have such lookouts stationed as are necessary in accordance with the best practice of seamen, having in mind the special conditions, the results to be accomplished, and the physical limitations of personnel and material. When under way during low visibility, or when approaching or traversing congested traffic lanes or areas, he shall maintain at least one lookout stationed in the bow as far forward and as near the water as feasible under the circumstances. He shall take steps to insure that lookouts are proficient in their duties.

The U. S. Navy Regulations require as many lookouts as may be necessary. This must be considered in connection with the decisions of the courts as to the proper stations for lookouts at night and in a fog. The courts have repeatedly held that at night or in a fog there must be a lookout as far forward and as low as possible. In the case of a fog there should be an additional lookout aloft, for should it be a low fog he might be able to see over it. If the type of vessel, the weather or the maneuvers the vessel is engaged in would make it dangerous for the lookout to be stationed in the eyes of the ship he must be stationed elsewhere but must have an unobstructed view.

> In **Watts** *v.* **U. S.,** 123 Fed. 105, Judge Adams, in speaking on the question of the proper stations of the lookouts, held: "It is encumbent upon the *Columbia* to maintain lookouts as far forward and as near the water as possible and at a height above the water, as well as for the purpose of hearing as seeing. The part of the bridge upon which the lookouts were stationed was ninety-four feet from the stem and thirty-seven feet six inches above the water. The vessels were approaching each other at an angle of twelve to fifteen degrees, and no excuse can be found for a failure to have lookouts forward, and there was no reason why they should not have been stationed at the stem, which, besides

being so much nearer any approaching object, was about fifteen feet closer to the water. The necessity of having a lookout aloft, also, under the circumstances was obvious."

In the case of the **Vedamore**, 137 Fed. 844, the Circuit Court of Appeals held that a lookout should be placed in the bow of a ship and that the bow is the best position from which to hear sounds and observe objects. This decision was cited with approval in the case of **Brigham** *v.* **Luckenbach**, 140 Fed. 325.

The Supreme Court of the United States in the case of the **Ottawa**, 3 Wall. 268, 272, held: "Proper lookouts are competent persons other than the Master and the helmsman, properly stationed for that purpose, on the forward part of the vessel; and the pilot house in the night time, especially if it is very dark, and the view obstructed, is not the proper place. Lookouts stationed in positions where the view forward or on the side to which they are assigned, is obstructed, either by the lights, sails, rigging or spars of the vessel, do not constitute a compliance with the requirement of the law; and in general, elevated positions, such as the hurricane deck, are not so favorable situations as those more usually selected on the forward part of the vessel, nearer the stem. Persons stationed on the forward deck are nearer the waterline, and consequently are less likely to overlook small vessels, deeply laden, and more readily ascertain their exact course and movement."

In the case of the **Eastern Dredging Co.** *v.* **Winnisimmet Co.**, 162 Fed. 860, the court held as follows: "The Supreme Court has been constantly rigid in holding vessels to maintaining lookouts as far forward and as near the water as possible. Especially where the water is dark, with otherwise a fairly clear night, it is important that the lookout should be as near it as possible, in order that his eye may follow the surface, and thus be in a position to detect anything low down which may be approaching."

In **Chamberlin** *v.* **Ward**, Mr. Justice Clifford said: "Steamers navigating in the thoroughfares of commerce must have constant and vigilant lookouts stationed in proper places on the vessel, and charged with the duty for which lookouts are required, and they must be actually employed in the performance of the duty to which they are assigned. To constitute a compliance with the requirements of the law, they must be persons of suitable experience, properly stationed on the vessel, and actually and vigilantly employed in the performance of the duty; and for a failure in either of those particulars the vessel and her owners are responsible."

In the **Felix Taussig**, Judge Hunt said: "The excuse offered by the lookout, that the pilot was in charge cannot be accepted. A lookout must use his ears, as well as his eyes, and must report what he hears as well as what he sees . . ."

As regards the precautions which may be required by the ordinary practice of seamen and the special circumstances of the case, the most common is that of stopping the engines in cases of uncertainty as to the actions of another vessel when the situation demands. If collision is imminent, it is usually well to stop and back, for then, if there be a collision, the resulting damage is much less.

Paris-Besseggen, 1930 A.M.C. 153: . . . "What is the proper speed for the navigation of a steam vessel must necessarily depend upon the particular circumstances of each case.

"It was also the duty of the *Paris* to stop in the presence of danger, or even of anticipated danger, due to the proximity of the tug and the uncertainties of her movements." (New York, 175 U. S. 187; Fed. 560, 563, 565.)

In **New York** (supra), Mr. Justice Brown said, at pages 201 and 207: "Nothing is better settled than that, if a steamer be approaching another vessel which has disregarded her signals, or whose position or movements are uncertain, she is bound to stop until her course be ascertained with certainty.

"The lesson that steam vessels must stop their engines in the presence of danger, or even of anticipated danger, is a hard one to learn, but the failure to do so has been the cause of the condemnation of so many vessels that it would seem that these repeated admonitions must ultimately have some effect. . ."

Another situation covered by the special circumstances of the case is when a tug is in a heavy tideway and unable to stop or reverse, because the tow would crowd down upon her. In ordinary cases a tug with tow has no special privileges, but such a case as mentioned would place the tug and other vessels approaching her under the Rule of Special Circumstances.

Again, it is the rule of good seamanship that when two vessels meet at a bend in a narrow channel, the one proceeding against the current should stop and wait for the one going with the current to make the turn.

The above are cited as some of the precautions required by the ordinary practice of seamen. It would be impossible to state all the conditions which might be brought up under this rule.

Reservation of Rules for Harbors and Inland Navigation.

Art. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made, by local authority, relative to the navigation of any harbor, river, or inland waters.

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. The international code signal of distress indicated by N C.

Third. The distance signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball.

Article 29 probably has wider application than any other article. It supplements all the rules by its reference to the ordinary practice of seamen and the special circumstances of the case. Whenever action is taken in obedience to the rules the mariner must bear in mind that should his action be in accordance with the letter of the law and yet not in accordance with the ordinary practice of seamen or be not in accordance with the special circumstances of the case he is at fault.

Article 27, "The General Prudential Rule," applies only under very definite conditions, but Article 29, "The Rule of Precaution" or "The Rule of Good Seamanship," is always applicable.

Lights on United States Naval Vessels and Revenue Cutters.

Art. 30. The exhibition of any light on board of a vessel of war of the United States or a Coast Guard cutter may be suspended whenever, in the opinion of the Secretary of the Navy, the commander in chief of a squadron, or the commander of a vessel acting singly, the special character of the service may require it.

Article 30 of the International Rules precludes the possibility of seagoing vessels in Inland waters attempting to justify any action not in accordance with Inland Rules on the basis that they are not bound by such local rules.

Article 30 of the Inland Rules gives to men-of-war of the United States permission to run darkened when in Inland waters provided the Secretary of the Navy or the Senior Officer present considers such action desirable. It should be noted that no such provision is to be found in the International Rules.

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore, the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

A continuous sounding with any fog-signal apparatus, or firing a gun.

At night—

First. Flames on the vessel, as from a burning tar barrel, oil barrel, and so forth.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. Flames on the vessel (as from a burning tar barrel, oil barrel, and so forth).

Third. Rockets or shells throwing stars of any color or description, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

"By act of Congress, approved August 21, 1935" "Orders to helmsmen on all vessels navigating waters of the United States, and on all vessels of the United States navigating any waters or seas. . . ."

Second. A continuous sounding with any fog-signal apparatus, or firing a gun.

ARTICLE 32—(Inland Only).

All orders to helmsmen shall be given as follows:

"'Right Rudder' to mean 'Direct the vessel's head to starboard.' 'Left Rudder' to mean 'Direct the vessel's head to port.'"

(Act of Congress approved August 21, 1935.)

The following Act of Congress fixing the penalty for failure to stand by after an accident was placed in effect by Presidential Proclamation on 18 November, 1890.

Whereas an Act of Congress in regard to collisions at sea was approved September 4, 1890, the said Act being in the following words:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in every case of collision between two vessels it shall be the duty of the master or person in charge of each vessel, if and so far as he can do so without serious danger to his own vessel, crew, and passengers (if any), to stay by the other vessel until he has ascertained that she has no need of further assistance, and to render to the other vessel, her master, crew, and passengers (if any) such assistance as may be practical and as may be necessary in order to save them from any danger caused by the collision, and also to give to the master or person in charge of the other vessel the name of his own vessel and her port of registry, or the port or place to which she belongs, and also the name of the ports and places from which she is bound. If he fails to do so, and no reasonable cause for such failure is shown, the collision shall, in the absence of proof to the contrary, be deemed to have been caused by his wrongful act, neglect or default.

"SEC. 2. That every master or person in charge of a United States vessel who fails, without reasonable cause, to render such assistance or give such information as aforesaid shall be deemed guilty of a misdemeanor, and shall be liable to a penalty of one thousand dollars, or imprisonment for a term not exceeding two years; and for the above sum the vessel shall be liable and may be seized and proceeded against by process in any district court of the United States by any person; one-half such sum to be payable to the informer and the other half to the United States.

"SEC. 3. That this Act shall take effect at a time to be fixed by the President by Proclamation issued for that purpose."

In the case of collision, the United States law requires that immediately after the occurrence a statement thereof and of the circumstances under

which the accident occurred be entered in the official log. The official log is, of course, what has become generally called the deck log. In addition to the deck log, an engineering log must be kept. In the U. S. Navy there is kept in addition to the official logs a quartermaster's note book and a bell book. In the quartermaster's note book the quartermaster makes notes of all happenings during his watch. The "bell book" is a record kept in the engine room of all orders to the engines.

The method of keeping the above records may play a large part in determining responsibility in case of a collision. Logs which are vague, interlined or erased immediately raise a doubt as to their authenticity in the mind of the court. All entries in the deck and engineering logs, bell books an quartermaster's note books should be made in a careful, concise and legible manner. No erasures, changes, alterations or obliterations should be made without the direct order of the commanding officer and he should not direct such changes unless the entry be materially erroneous.

In case of a collision the ship's log should show the time and place of collision, relative position of the vessel from the time first seen until the time of the collision; the condition of the weather, visibility, wind, sea, tide, cloudy or clear; steps taken to avoid the collision, signals given and heard; whether or not lights on own vessel and other vessel were lighted and showing through their required arc; when and where lights were first observed, lookouts stationed and their reports; bearings taken together with times.

In the **Richmond** case the court said: "A most significant bearing upon the vessel's lights is the fact that, although the failure of the vessel in this regard is made the chief basis of the steamer's defense, the fact that such lights did not exist was not made a record of at the time of the collision, either in the steamer's log or the protest made the next day. Both the log and the protest utterly fail to make any reference to such conditions, and it is hard to believe that so important an omission would have been made had the lights not been burning. Nothing could have been more material to the steamer, nothing would so likely have accounted for the collision, and probably have vindicated the steamer. The **Utopia,** (D. C.) 1 Fed. 892; the **Frostburg,** (D. C.) 25 Fed. 451. The object of the log was to have a record made at the time of the then existing facts. The **Newfoundland,** (D. C.) 89 Fed. 510-515. Congress by the Act of the 14th of February, 1900, amending Section 4290 of the Revised Statutes, has specifically required the facts of collision to be set forth in the log. This significant conduct on the part of the steamer, together with the other facts and circumstances in the case, convince me that the schooner's lights were properly set and burning at the time of the collision."

In the **Buenos Aires** case the Circuit Court of Appeals for the Second Circuit said: "The appellant's brief considers 'the ques-

tion of whether or not the bark was displaying her green side-light as decisive of the entire case.' The court concedes it to be decisive. But if it be decisive and no green light was displayed by the bark, as required by law, those in command of the steamer certainly would have had the absence of the light at the time of collision strongly impressed upon their mind and the absence of the light would have been noted in the log of the steamer. But no such entry in the log was made at the time. . . . It certainly is a matter of great significance that in a matter of such vital importance as the absence of or failure to see side-lights of a sailing vessel, which was sent to the bottom by a collision with a steamer, the log of the steamer made no mention of the important and essential circumstances that the bark was displaying no lights at the time the collision occurred. It is hard to believe that so important an omission would have occurred had the lights not been burning."

The following Pilot Rules are quoted because of their wide application. They are not complete. The complete Pilot Rules are found in the publications previously mentioned.

RULES FOR LIGHTS TO BE CARRIED BY FERRYBOATS NAVIGATING THE HARBORS, RIVERS, AND INLAND WATERS OF THE UNITED STATES, EXCEPT THE GREAT LAKES AND THEIR CONNECTING AND TRIBUTARY WATERS AS FAR EAST AS MONTREAL AND THE RED RIVER OF THE NORTH AND RIVERS EMPTYING INTO THE GULF OF MEXICO AND THEIR TRIBUTARIES.[1]

[Authority: Section 2, act of Congress approved June 7, 1897.]

Ferryboats propelled by machinery and navigating the harbors, rivers, and other inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal and the Red River of the North and rivers emptying into the Gulf of Mexico and their tributaries, shall carry the range lights and the colored side lights required by law to be carried on steam vessels navigating those waters, except that *double-end ferryboats* shall carry a central range of clear, bright, white lights, showing all around the horizon, placed at equal altitudes forward and aft, also on the starboard side a green light, and on the port side a red light, of such character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and so constructed as to show a uniform and unbroken light over an arc of the horizon of ten points of the compass, and so fixed as to throw the light from right ahead to two points abaft the beam on their respective sides.

The green and red lights shall be fitted with inboard screens projecting at least three feet forward from the lights, so as to prevent them from being seen across the bow.

Local inspectors in districts having ferryboats shall, whenever

[1] See act of Congress approved June 9, 1910, effective on and after July 9, 1910, prescribing lights that shall be carried by certain classes of vessels of not more than 65 feet in length, amendatory of these rules.

the safety of navigation may require, designate for each line of such boats a certain light, white or colored, which will show all around the horizon, to designate and distinguish such lines from each other, which light shall be carried on a flagstaff amidships, fifteen feet above the white range lights.

RULES FOR LIGHTS FOR BARGES AND CANAL BOATS IN TOW OF STEAM VESSELS AND FOR LIGHTS AND DAY SIGNALS FOR DREDGES, VESSELS WORKING ON WRECKS, ETC., NAVIGATING THE HARBORS, RIVERS, AND OTHER INLAND WATERS OF THE UNITED STATES, EXCEPT THE GREAT LAKES AND THEIR CONNECTING AND TRIBUTARY WATERS AS FAR EAST AS MONTREAL AND THE RED RIVER OF THE NORTH AND RIVERS EMPTYING INTO THE GULF OF MEXICO AND THEIR TRIBUTARIES.

[Authority: Section 2, act of Congress approved June 7, 1897.]

These rules concerning lights shall be complied with in all weathers from sunset to sunrise and shall be effective on and after September 1, 1914.

LIGHTS FOR BARGES AND CANAL BOATS IN TOW OF STEAM VESSELS ON CERTAIN INLAND WATERS ON THE SEABOARD, EXCEPT THE HUDSON RIVER AND ADJACENT WATERS AND LAKE CHAMPLAIN.

On the harbors, rivers, and other inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal and the Red River of the North and rivers emptying into the Gulf of Mexico and their tributaries, and except on the waters of the Hudson River and its tributaries from Troy to the boundary lines of New York Harbor off Sandy Hook, as defined pursuant to section 2 of the act of Congress of February 19, 1895, the East River, and Long Island Sound (and the waters entering thereon, and to the Atlantic Ocean), to and including Narragansett Bay, R. I., and tributaries, and Lake Champlain, barges (except scows) and canal boats in tow of steam vessels shall carry lights as follows:

Barges and canal boats towing astern of steam vessels, when towing singly, or what is known as tandem towing shall each

carry a green light on the starboard side and a red light on the port side, and a white light on the stern, except that the last vessel of such tow shall carry two lights on her stern, athwartship, horizontal to each other, not less than five feet apart, and not less than four feet above the deck house, and so placed as to show all around the horizon.

When two or more boats are abreast, the colored lights shall be carried at the outer sides of the bows of the outside boats. Each of the outside boats in last tier of a hawser tow shall carry a white light on her stern.

The white light required to be carried on stern of a barge or canal boat carrying red and green side lights shall be carried in a lantern so constructed that it shall show an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, and shall be of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles.

Barges or canal boats towing alongside a steam vessel shall, if the deck, deck houses, or cargo of the barge or canal boat be so high above water as to obscure the side lights of the towing steamer when being towed on the starboard side of the steamer, carry a green light upon the starboard side; and when towed on the port side of the steamer, a red light on the port side of the barge or canal boat; and if there is more than one barge or canal boat abreast, the colored lights shall be displayed from the outer side of the outside barges or canal boats.

The colored side lights referred to in these rules for barges and canal boats in tow shall be fitted with inboard screens, so as to prevent them from being seen across the bow, and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles, and so constructed as to show a uniform and unbroken light over an arc of the horizon of ten points of the compass, and so fixed as to throw the light from right ahead to two points abaft the beam on either side. The minimum size of glass globes shall not be less than six inches in diameter and five inches high in the clear.

Scows when being towed by steam vessels on the waters covered by the first paragraph of these rules shall carry a white light at each end of each scow, except that when such scows are massed in tiers, two or more abreast, each of the outside scows

shall carry a white light on its outer bow, and the outside scows in the last tier shall each carry, in addition, a white light on the outer part of the stern. The white light shall be carried not less than eight feet above the surface of the water, and shall be so placed as to show an unbroken light all around the horizon, and shall be of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least five miles.

LIGHTS FOR BARGES AND CANAL BOATS IN TOW OF STEAM VESSELS ON THE HUDSON RIVER AND ADJACENT WATERS AND LAKE CHAMPLAIN.[2]

All nondescript vessels known as scows, car floats, lighters, and vessels of similar type, navigating the waters referred to in the following rules, shall carry the lights required to be carried by barges and canal boats in tow of steam vessels, as prescribed in such rules.

Barges and canal boats, when being towed by steam vessels on the waters of the Hudson River and its tributaries from Troy to the boundary lines of New York Harbor off Sandy Hook, as defined pursuant to section 2 of the act of Congress of February 19, 1895, the East River and Long Island Sound (and the waters entering thereon, and to the Atlantic Ocean), to and including Narragansett Bay, R. I., and tributaries, and Lake Champlain, shall carry lights as follows:

Barges and canal boats being towed astern of steam vessels when towing singly shall carry a white light on the bow and a white light on the stern.

When towing in tandem, "close up," each boat shall carry a white light on its stern and the first or hawser boat shall, in addition, carry a white light on its bow.

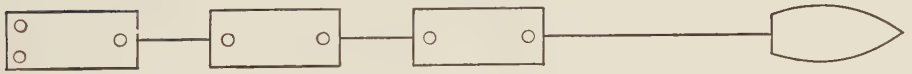
When towing in tandem with intermediate hawser between the various boats in the tow, each boat shall carry a white light on the bow and a white light on the stern, except that the last vessel in the tow shall carry two white lights on her stern, athwartship,

[2] Adopted by the Board of Supervising Inspectors on January 27, 1933, and approved by the Secretary of Commerce on February 6, 1933.

Singly

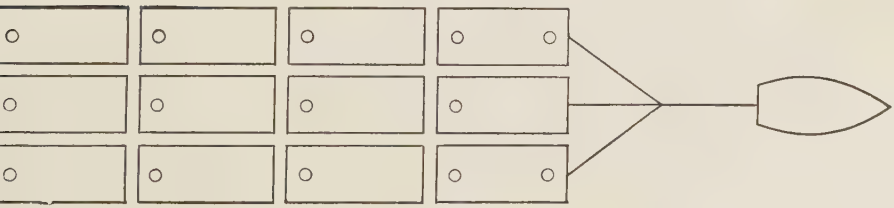
Tandem – Close-up

Tandem with Intermediate Hawser



Two or more Abreast in one Tier

Two or more Abreast and in more than one Tier



horizontal to each other, not less than five feet apart and not less than four feet above the deck house, and so placed as to show all around the horizon: *Provided,* That seagoing barges shall not be required to make any change in their seagoing lights (red and green) on waters coming within the scope of these rules, except that the last vessel of the tow shall carry two white lights on her stern, athwartship, horizontal to each other, not less than five feet apart, and not less than four feet above the deck house, and so placed as to show all around the horizon.

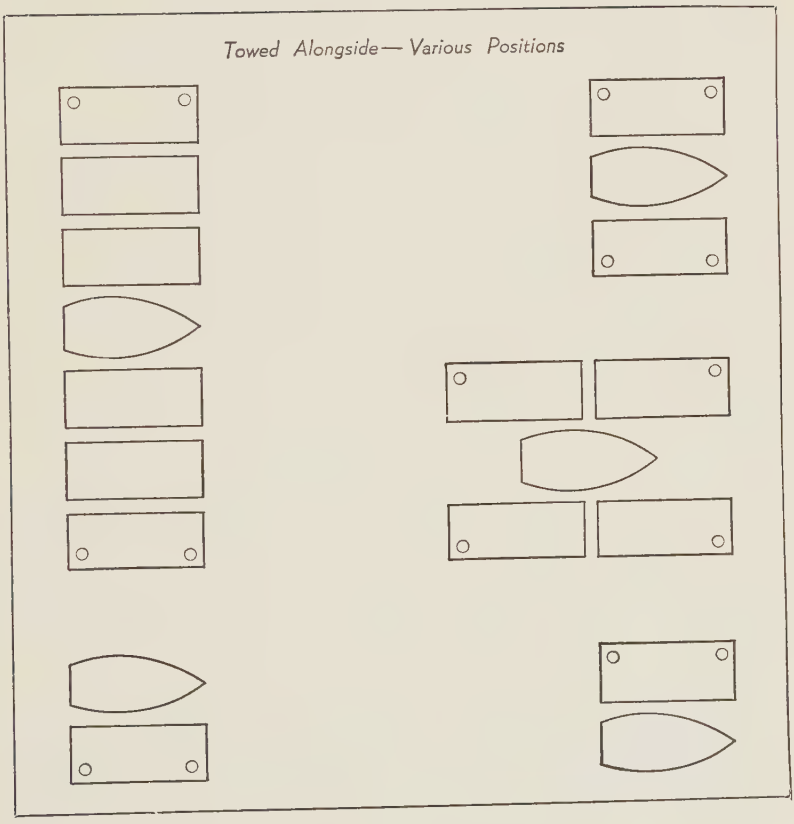
Barges and canal boats when towed at a hawser, two or more abreast, when in one tier, shall each carry a white light on the stern and a white light on the bow of each of the outside boats.

When in more than one tier, each boat shall carry a white light on its stern and the outside boats in the hawser or head tier shall each carry, in addition, a white light on the bow.

The white bow lights for barges and canal boats referred to in the preceding rules shall be carried at least ten feet and not more than thirty feet abaft the stem or extreme forward end of the vessel. On barges and canal boats required to carry a white bow light, the white light on bow and the white light on stern shall each be so placed above the hull or deck house as to show an unbroken light all around the horizon, and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles.

When nondescript vessels known as scows, car flats, lighters, barges or canal boats, and vessels of similar type, are towed alongside a steam vessel, there shall be displayed a white light at the outboard corners of the tow.

Plate No. 135



Dump Scows[3] utilized for the transportation and disposal of garbage, street sweepings, ashes, excavated material, dredgings, etc., when navigating on the Hudson River or East River or the waters tributary thereto between loading points on these waters and the dumping grounds established by competent authority outside the line dividing the high seas from the inland waters of New York Harbor, shall, when towing in tandem, carry, instead of the white lights previously required, red and green side lights on the respective and appropriate sides of the scow in addition to the white light required to be shown by an overtaken vessel.

The red and green lights herein prescribed shall be carried at an elevation of not less than eight feet above the highest deck house, upon substantial uprights, the lights properly screened and so arranged as to show through an arc of the horizon of ten points of the compass, that is, from right ahead to two points abaft the beam on either side and visible on a dark night with a clear atmosphere a distance of at least two miles.

Provided, That nothing in these rules shall be construed as compelling barges or canal boats in tow of steam vessels, passing through any waters coming within the scope of these rules where lights for barges or canal boats are different from those of the waters whereon such vessels are usually employed, to change their lights from those required on the waters from which their trip begins or terminates; but should such vessels engage in local employment on waters requiring different light from those where they are customarily employed, they shall comply with the local rules where employed.

[3] Rule relating to dump scows adopted by the executive committee of the Board of Supervising Inspectors on November 18, 1924, and approved by the Secretary of Commerce on November 19, 1924. Later ratified by the Board of Supervising Inspectors and approved by the Secretary of Commerce.

RULES FOR LIGHTS AND DAY SIGNALS TO BE CARRIED BY VESSELS, DREDGES OF ALL TYPES, AND VESSELS WORKING ON WRECKS OR OTHER OBSTRUCTIONS TO NAVIGATION, OR MOORED FOR SUBMARINE OPERATIONS OR MADE FAST TO A SUNKEN OBJECT WHICH MAY DRIFT WITH THE TIDE OR BE TOWED.[4]

[Authority: Section 2, act of Congress approved June 7, 1897, as amended by act of Congress approved May 25, 1914.]

RULE 3. RULE FOR DREDGES WHICH ARE HELD IN STATIONARY POSITION BY MOORINGS OR SPUDS.

Dredges which are held in stationary position by moorings or spuds shall display by day two red balls not less than two feet in diameter and carried in a vertical line not less than three feet nor more than six feet apart, and at least fifteen feet above the deck house and in such a position where they can best be seen from all directions. By night they shall display a white light at each corner, not less than six feet above the deck, and in addition thereto there shall be displayed in a position where they may best be seen from all directions two red lights carried in a vertical line not less than three feet nor more than six feet apart, and not less that fifteen feet above the deck. When scows are moored alongside a dredge in the foregoing situation they shall display a white light on each outboard corner, not less that six feet above the deck.

RULE 4. RULE FOR SELF-PROPELLING SUCTION DREDGES UNDER WAY WITH THEIR SUCTION ON THE BOTTOM.

Self-propelling suction dredges under way with their suction on the bottom shall display by day the same signals as are used to designate any steamer not under control; that is to say, two black balls not less than two feet in diameter and carried not less than fifteen feet above the deck house, and where they may best be seen from all directions.

[4] Adopted by executive committee of Board of Supervising Inspectors on July 22, 1914, and approved by the Secretary of Commerce on July 28, 1914. Adopted by Board of Supervising Inspectors on January 20, 1915, and approved by the Secretary of Commerce on April 12, 1915.

By night they shall carry, in addition to the regular running lights, two red lights of the same character as the masthead light, in the same vertical plane and underneath the masthead light, the red lights to be not less than three feet nor more than six feet apart and the upper red light to be not less than four feet and not more than six feet below the white masthead light, and on or near the stern two red lights in the same vertical plane not less than four feet nor more than six feet apart, to show through four points of the compass; that is, from right astern to two points on each quarter.

RULE 5. RULE FOR VESSELS WHICH ARE MOORED OR ANCHORED AND ENGAGED IN LAYING PIPE OR OPERATING ON SUBMARINE CONSTRUCTION OR EXCAVATION.

Vessels which are moored or anchored, and engaged in laying pipe or operating on submarine construction, or excavation shall display by day, not less than fifteen feet above the deck, where they can best be seen from all directions, two balls not less than two feet in diameter, in a vertical line not less than three feet and not more than six feet apart, the upper ball to be painted in alternate black and white vertical stripes six inches wide, and the lower ball to be painted a solid bright red. By night they shall display three red lights, carried in a vertical line not less than three feet nor more than six feet apart and not less than fifteen feet above the deck, and in such position as may best be seen from all directions.

All the lights required by these special rules for dredges, wrecking boats, lighters, etc., shall be of such size and character as to be visible on a dark night with a clear atmosphere for a distance of at least two miles.

RULE 8. RULE FOR PASSING SIGNALS.

Vessels intending to pass dredges or other types of floating plant working in navigable channels, when within a reasonable distance therefrom and not in any case over a mile, shall indicate such intention by blowing the passing signal prescribed in the local pilot rules for vessels under way, which shall be answered in the usual manner from said plant if the channel is clear and

the approaching vessel may pass on the course indicated; otherwise the floating plant shall sound the alarm or danger signal and the approaching vessel shall slow down or stop and await further signal from the plant.

When the pipe line from a dredge crosses the channel in such a way that an approaching vessel, owing to excessive draft or for other reasons, cannot pass around the pipe line or dredge, a signal shall be given from the vessel by sounding four blasts of the whistle, which shall be answered by a like signal from the dredge. The pipe line shall then be opened for the passage of the vessel as soon as practicable; when the line is open ready for passage, the dredge shall so indicate by sounding the usual passing signal, and the approaching vessel shall promptly pass the dredge.

RULE 9. RULE FOR SPEED OF VESSELS PASSING FLOATING PLANT WORKING IN CHANNELS.

Steamers, with or without tows, passing floating plant working in channels, shall reduce their speed sufficiently to insure the safety of both the said plant and themselves, and when passing within 200 feet of the said plant their speed shall not exceed five miles per hour. While passing over lines of the said plant, propelling machinery shall be stopped.

RULE 10. RULE FOR LIGHT-DRAFT VESSELS PASSING FLOATING PLANT.

Vessels whose draft permits shall keep outside of the buoys marking the ends of mooring lines of floating plant working in channels.

RULE 12. RULE FOR OBSTRUCTION OF CHANNEL BY FLOATING PLANT.

Channels shall not be unnecessarily obstructed by any dredge or other floating plant. While vessels are passing such plant, all lines running therefrom across the channel on the passing side, which may interfere with or obstruct navigation, shall be slacked to the bottom of the channel.

RULE 13. RULE FOR PROTECTION OF MARKS PLACED FOR THE GUIDANCE OF FLOATING PLANT.

Vessels shall not run over anchor buoys, or buoys, stakes, or other marks placed for the guidance of floating plant working in channels; and shall not anchor on the ranges of buoys, stakes, or other marks placed for the guidance of such plant.

NOTE.—If it is necessary to prohibit or limit the anchorage or movement of vessels within certain areas in order to facilitate the work of improvement, application should be made through official channels for establishment by the Secretary of War of special or temporary regulations for this purpose.

RULE 14. RULE FOR CLEARING OF CHANNELS.

When special or temporary regulations have not been prescribed and action under these rules and regulations will not afford clear passage, floating plant in narrow channels shall, upon notice, move out of the way of vessels a sufficient distance to allow them a clear passage. Vessels desiring passage shall, however, give the master of the floating plant ample notice in advance of the time they expect to pass.

RULE PERTAINING TO THE USE OF SEARCHLIGHTS.

Any master or pilot of any steam vessel who shall flash or cause to be flashed the rays of the searchlight into the pilot house of a passing vessel shall be deemed guilty of misconduct and shall be liable to have his license suspended or revoked.

RULE PROHIBITING UNNECESSARY SOUNDING OF THE STEAM WHISTLE.

[Authority: Act of Congress approved February 8, 1907.]

Unnecessary sounding of the steam whistle is prohibited within any harbor limits of the United States. Whenever any licensed officer in charge of any steamer authorizes or permits such unnecessary whistling, upon conviction thereof before any board of inspectors having jurisdiction, such officer shall be suspended from acting under his license as the inspectors trying the case may deem proper.

RULE PROHIBITING THE CARRYING OF UNAUTHORIZED LIGHTS ON STEAM VESSELS.

Any master or pilot of any steam vessel who shall authorize or permit the carrying of any light, electric or otherwise, not required by law, on the outside structure of the cabin or hull of the vessel that in any way will interfere with distinguishing the signal lights shall, upon conviction thereof before any board of inspectors having jurisdiction, be deemed guilty of misconduct and shall be liable to have his license suspended or revoked.

CHAPTER XIII.

MANEUVERING TO AVOID COLLISION.

§ I.

In daylight and clear weather, the avoidance of collision should be simple enough. It is in darkness and periods of reduced visibility that dangers and difficulties increase, and this Chapter will, therefore, deal with steamers meeting and crossing at night.

It must be borne in mind that turbine ships respond less quickly to changes in engine speed than do ships having the large screws that go with reciprocating engines. Also that the power available for backing is proportionally less than that of reciprocating engines.

The result is that turbine ships must rely more upon the rudder, and must be especially careful to avoid situations demanding quick and handy maneuvering.

§ II.

STEAMERS MEETING.

Attention has already been called to the fact that this situation is not as simple as it at first appears, for the reason that vessels which seem to be approaching each other "end-on" or nearly "end-on," may in fact be crossing at a considerable angle.

There is no rule which can be laid down to eliminate the danger of such misunderstandings; but there is a certain gain in recognizing the existence of the danger and the necessity for watchfulness. If the rudder is to be put right this should be done while the ships are separated by a perfectly safe distance, and the course changed to starboard sufficiently to make sure of shutting out the green light from the view of the other ship. It is of course impossible to do this in a narrow channel, nor will it be important to do it there, as each vessel will know the course that the other must be steering; but the change of course should always be made as early as the channel permits.

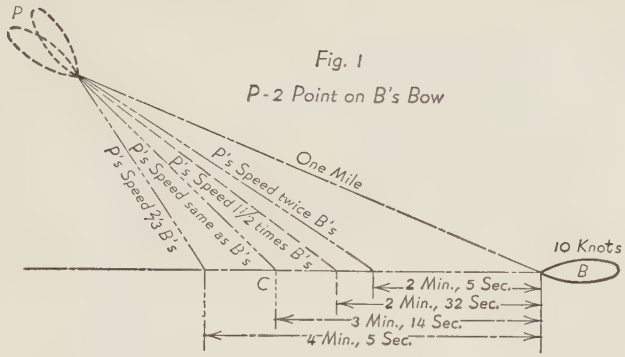


Fig. 1
P-2 Point on B's Bow

The time Intervals shown assume B's speed as 10 Knots, but can be easily corrected for any other speed.
Ships are not drawn to scale.

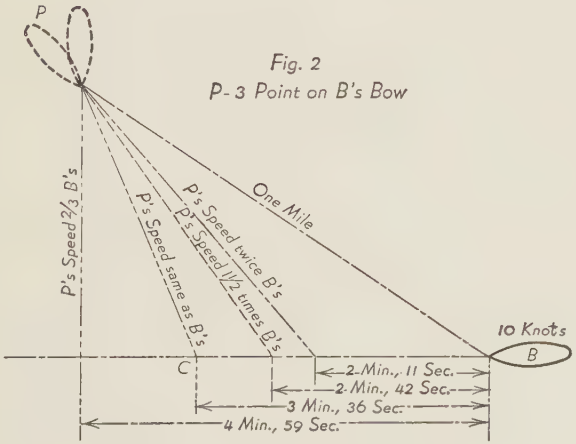
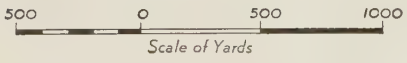


Fig. 2
P-3 Point on B's Bow



MANEUVERING TO AVOID COLLISION, SHOWING THE POINTS AT WHICH *B* AND *P* WILL MEET FOR VARIOUS RELATIVE SPEEDS.

When meeting another vessel in a narrow channel, there is danger in changing course too much, as to do so opens the broadside to a possible blow from the other ship. A small change made promptly is safer than a greater change after the ships are close aboard. On the other hand, there is the danger already pointed out, that, at night, a small change of course will not be seen by the other ship. In this situation, range-lights are especially valuable, as giving instant notice of the slightest change in the heading of a vessel seen end-on or nearly so.

In navigating crowded channels, pilots try to avoid changing course; preferring, whenever it can be done with safety, to keep clear of other vessels by reducing or increasing speed. This is less confusing than changes of course where several vessels are trying to keep clear of each other.

§ III.

STEAMERS CROSSING.

Note.—In this section, the steamer having the other on her own starboard hand is called "B" (burdened); the other "P" (privileged).

As preliminary to a detailed discussion of cases arising under this heading, attention is directed to the figures of Plates **136** and **137**, in which the vessels are assumed to be separated by one mile, and the courses plotted which *P* must be steering, for various rates of speed, in order that there shall be danger of a bow-to-bow collision with *B*.[1]

We do not attempt here to draw any conclusions which involve a knowledge on the part of either vessel, of the course or speed of the other.

It is apparent from these figures that, if there is to be a collision, the point at which it will take place depends upon the relative speed of the two ships. If the speeds are equal, it will be at *C*, equidistant from *B* and *P*. If *P* has the greater speed, the point of meeting is crowded back towards *B*, and the space available for *B* to maneuver is reduced. If, on the other hand *P's*

[1] We cannot, of course, disregard the length of the ships; but as a basis of argument we deal here with the bows only. The figures will make it clear in what way the argument must be modified to include the meeting of the bow of one ship with the stern of the other.

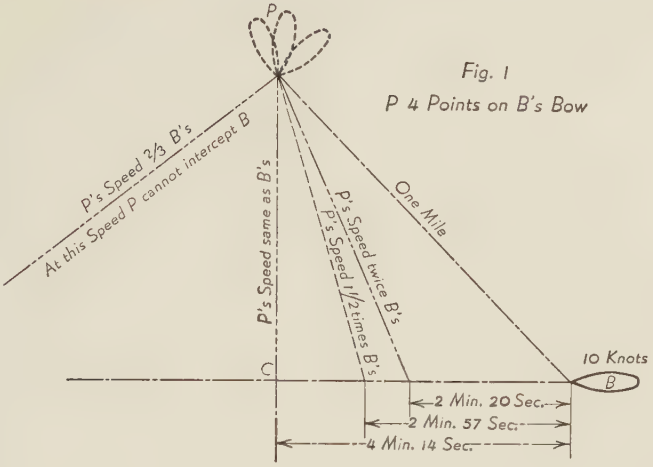


Fig. 1
P 4 Points on B's Bow

The time intervals shown, assume B's speed as 10 knots but can be easily corrected for any other speed.

Ships are not drawn to scale.

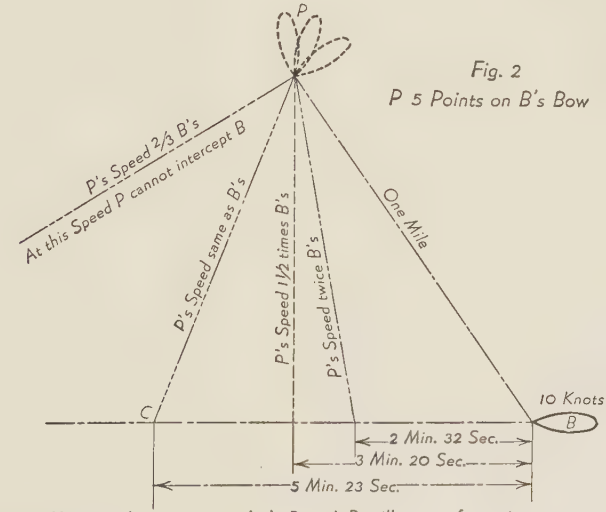
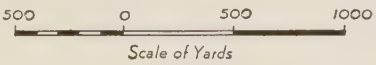


Fig. 2
P 5 Points on B's Bow

Showing the points at which B and P will meet, for various relative speeds.



speed is less than *B's*, the point of intersection recedes, and the space at *B's* command is correspondingly increased. It follows from this that if *B* is running at a low speed and finds another vessel closing in on her without change of bearing, she will know that the space at her command for maneuvering is comparatively limited, as, in all probability, the point of intersection of the courses is not far ahead.

As regards *P*, if it happens that she is running at very high speed, she, too, will know that in all probability the courses intersect near *B* and that *B* has probably but little space for clearing her (*P's*) line. It may therefore be urged that, so far as *P* is concerned, the obligation upon her to act for the avoidance of collision, under Art. 21 of the Rules of the Road, will increase with her speed; that is to say, if her speed is so high that *B's* is not likely to equal it, she will know that her course is *probably* crossing *B's* at a point which leaves *B* but little space in which to maneuver for mutual safety.

As regards the *time* available in the cases illustrated in Plates **136** and **137**, we cannot discuss this without assuming a definite speed for *B*. In the figures, this is taken at 10 knots, so that *P's* speed becomes, for the courses laid down, 10, 15, 20 and 7 knots.

If *B's* speed is greater or less than 10 knots, the intervals must be changed correspondingly.

If we take the distance between the ships as greater or less than one mile, the scale of the figures must be changed.

With these speeds, we see that, when *P* is distant one mile and crossing without change of bearing, the bows of the two ships will meet after the intervals shown in the figures.

An important point brought out by the figures is that, if *P's* speed is materially less than *B's*, there are only certain bearings on which *P* can threaten collision. Suppose, for example, that *P's* speed is two-thirds of *B's* and that she bears four points on *B's* bow. She cannot by any possibility reach the line of *B's* course in time to intercept and collide with her. As the difference in speed increases, this point comes out more and more strikingly. If *B's* speed is three times *P's* there can be no collision if *P* is sighted more than 1¾ points on the bow.

It follows from this, that in the case of a steamer running at a speed so high that no vessel which is likely to cross her course can be expected to have anything like an equal speed, the danger sector is confined to a few points on either bow.

Take the case of an ocean liner, running at a speed of 20 knots, and consider her relation, for example, to sailing vessels crossing her route. These vessels will not have more than one-third to one-half her speed. To threaten collision, then, they must bear a very little on the bow, and can be cleared, in most cases, with a few degrees of rudder.

§ IV.

A large proportion of steamers meeting at sea approach each other on bearings from ahead to four points on the bow. It happens that this is, for reasons which will appear hereafter, the most dangerous bearing on which they can approach; and it results from this coincidence of the maximum frequency of occurrence with the maximum danger, that something like seventy-five per cent of all collisions reported are between vessels approaching each other on these bearings.

It will be convenient to distinguish two general classes of situations: 1st, Those arising under ordinary conditions, where vessels sight each other at normal distances and have plenty of time and space for maneuvering to avoid collision; and 2nd, Those in which they do not see each other until dangerously close. If any doubt exists as to whether they are dangerously close or not, it should of course be assumed that they are.

1st. Masthead lights are required by the law to be visible five miles, on a clear, dark night; and this law is fairly well complied with. We shall certainly not be in error if we assume that they will show four miles, and that the side-lights of a steamer will show half as far. If bearings are taken from the time the masthead lights are seen, the situation should be perfectly clear by the time the side-lights are made out, and if danger of collision has been found to exist *B* (the "burdened" ship) should be ready to act at once. She may give way by changing speed, or course, or both, but it is always simpler to change the course than to reduce the speed materially; and this has the further advantage that it gives notice to *P* (the "privileged" ship) of what has been done—provided the course can be changed sufficiently to open the red light. It will not usually be *necessary* to make so great a change as this, merely to insure passing astern but it is very desirable to do so if *P* is not too far on the bow, as it immediately

clears up the situation for both ships. The whistle signal required by the Rules of the Road, for a change of course, is an additional safeguard in this case, which could not be used for a mere reduction of speed. If, however, *P* is more than three or four points on the bow, it will suffice to slow as much as may be necessary to let her draw ahead, changing course later if it shall seem advisable.

In changing course to avoid collision, right rudder is required of *B* by the article which directs her whenever possible to pass astern of *P*.

2nd. If the vessels are dangerously close when they sight each other, *B* is relieved from the obligation to pass astern of *P* by the General Prudential Rule, unless it shall appear that this is the safest course that she can take. We shall find that, as a matter of fact, it is in a majority of cases the only course that can give her a hope of safety; and that right rudder is usually even more imperatively demanded of her in this case, than when the space available for maneuvering is greater.

The first impulse of many officers in such a situation is to turn away from the danger, and at the same time to reverse the engines with full power. This course is much more likely to cause collisions than to prevent them. If there is sufficient room for her to throw her stern clear of *B*, it may be right for *P* (the "privileged" vessel) to turn away, when in imminent danger of collision, but if she does this, so far from reversing her engines, she should, if possible, increase her speed, as her whole effort must be directed to getting across the bow of *B* as quickly as possible. On the other hand, *B* should reduce her speed, but should at the same time turn to starboard.

A vessel having sufficient room to swing her stern clear and turning away from another vessel to avoid collision, should always continue at full speed as the effort involved in this course is an attempt to cross the other vessel's bow. To turn away and slow is the surest possible way of bringing about collision.

To make it clear why *B* turns toward the danger instead of away from it, refer to Plates **138** and **139,** where *P* is placed, in the successive figures, on bearings from two to five points on *B's* bow and showing a red light. In such a situation, the action to be taken will not depend upon the exact distance between the ships. This distance is here taken, for convenience of plotting,

at 500 yards, but it may be more or less than this without modifying the principle involved, except in one special case to be hereafter considered.

As we cannot suppose that *B* in this case has time to watch for a change of bearing, or that she will have any information of *P's* course and speed beyond that given by a red and white light, we must consider that, so far as *B's* knowledge goes, *P* may be heading anywhere between the lines *PX* and *PY*. If, however, she is heading nearly along *PX*, she is safe to pass astern of *B*[1]; and if she is heading well off toward *PY*, the danger of collision, although it may exist, will be comparatively remote. The situation will not be one of serious emergency unless *P* is heading on some course within the sector *SPT*.

If *B* turns to starboard and reverses, using rudder and engines together to the best advantage, she will follow the heavy line (approximately). If she has twin screws and reverses the inner one, at the same time putting her rudder right, she will follow the light line. In either case, if she does not turn clear of the danger sector, she will cut only a few of its lines (that is to say, only a few of the possible courses of *P*); and she will at the same time present her stem to *P*, thus reducing, at once, the danger of collision and the damage to be expected if collision occurs. If she turns to port, she not only cuts every one of the courses of *P* within the danger sector, but she throws herself across *P's* path broadside on, inviting the most fatal blow that one ship can give another.

If it be contended that, in placing the ships 500 yards apart, we have taken too great a distance for urgent danger, the answer is that at less than this we approach the case in which collision is not only imminent but almost inevitable and for which no hard and fast rules can be laid down. Whether, in such a case, it is safer to turn toward the danger or away from it will depend largely upon the angle at which the courses converge, and when the vessels are very close together, we may assume that something will be known about this, since it is hardly to be supposed that two vessels within a few hundred yards of each other will

[1] It will be noted that *B* could, by turning with the starboard screw backing, collide with *P* even if *P* is heading along *PX*; but long before this could happen, *B* would see *P's* green light and would resume her course.

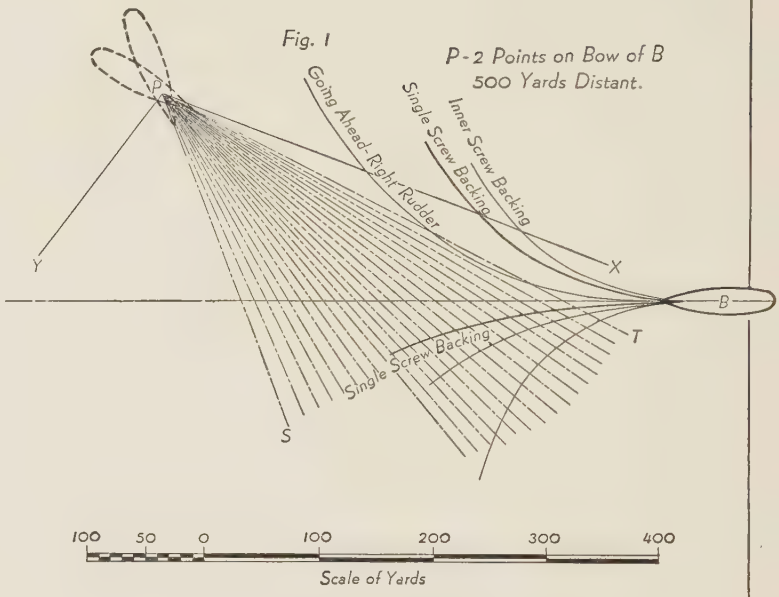


Fig. 1
P-2 Points on Bow of B
500 Yards Distant.
Going Ahead-Right Rudder
Single Screw Backing
Inner Screw Backing
Single Screw Backing
P
Y
X
B
T
S

100 50 0 100 200 300 400
Scale of Yards

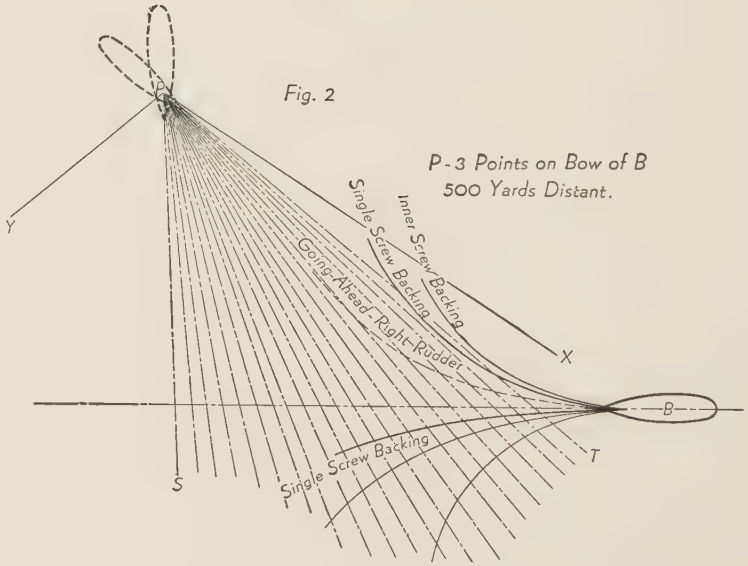
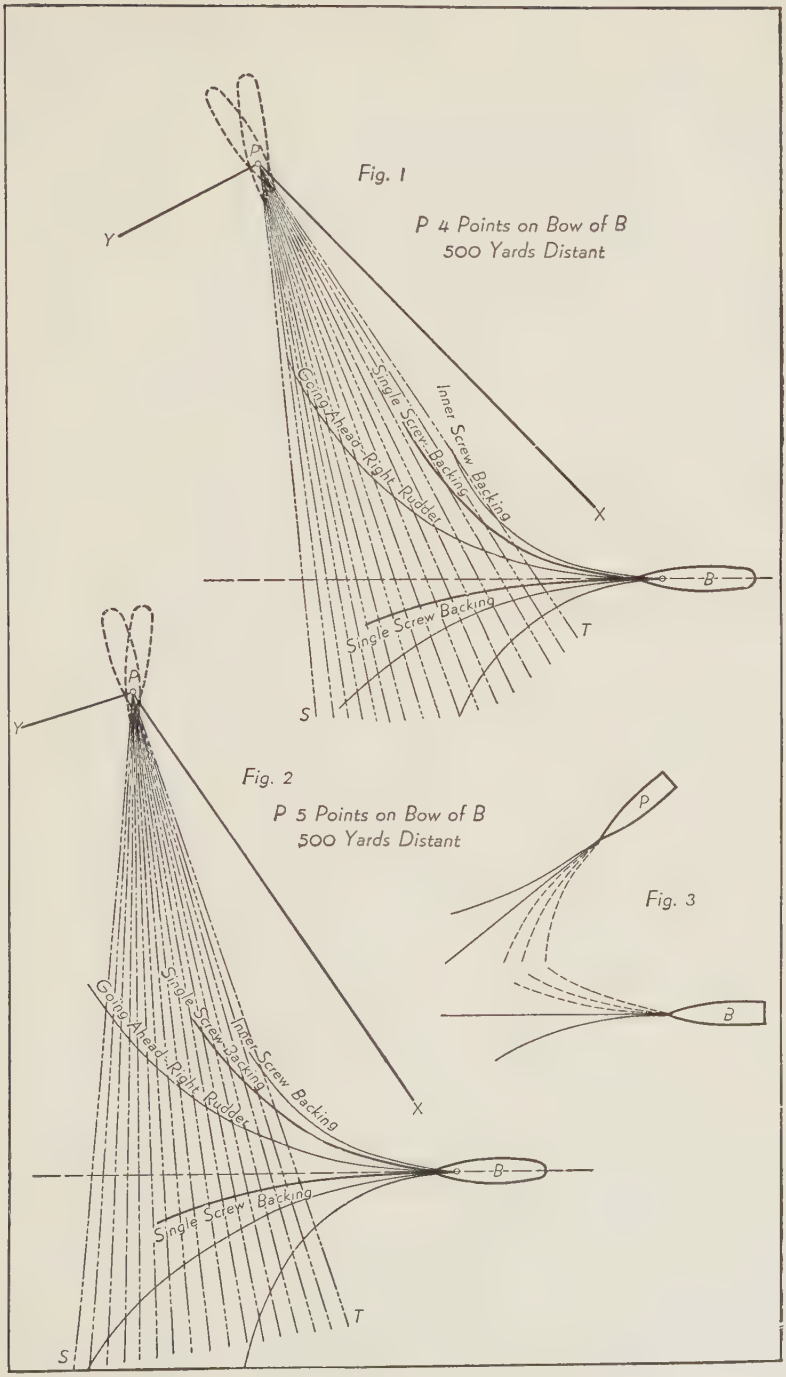


Fig. 2
P-3 Points on Bow of B
500 Yards Distant.
Single Screw Backing
Inner Screw Backing
Going Ahead-Right Rudder
Single Screw Backing
P
Y
X
B
T
S



MANEUVERING TO AVOID COLLISION.

not see something besides each other's side lights. If it is seen that the courses converge as in Fig. 3, Plate **139**, the ships being very close together, it is clear that each should turn away from the other, and stop. If *B* has twin-screws she would back the port screw full speed. If she has a single right-handed screw, it may be dangerous to back if *P* is very close.

In the case where *B* has *P* nearly on the beam, the importance of turning inward is less marked than when she is on the bow, and it is generally safe to slow or stop to let her draw ahead, or at least to let the situation declare itself clearly.

With regard to *P's* course when she finds herself called upon, under Art. 27, to act for the avoidance of collision with a vessel on her port hand (*B*), she should, in most cases, turn away, with right rudder, and keep her speed or if possible increase it. But this involves presenting her broadside to *B*; and if the ships are so close that it is evident collision cannot be avoided, there is no question that *P* should turn inward, presenting her bow as nearly as possible to *B*, and stopping; remembering, if she has a single (right-handed) screw, that backing will throw her head to starboard and may defeat the object of the maneuver. This is a situation for which it is impossible to lay down hard and fast rules; and all that is attempted here is to call attention to all the factors in the problem.

If *P* has twin screws, she should, if she puts her rudder left, reverse the inner (port) screw, and follow this up by reversing the other one as soon as she has begun to swing. There is a chance that the ships may still avoid each other, and if they meet, the damage will be less than if either of them strikes the other full on the broadside.

If *B* (a steamer) meets a sailing-vessel, her obligation to keep clear is the same whether the latter is on her starboard or her port hand. The law requires her, also, whenever the circumstances admit, to give way by passing astern. Where a right-handed single screw steamer is to turn to port to avoid collision with a vessel approaching from that side, it is important to remember that if the engines are reversed they will probably destroy the effect of the rudder, and throw the head to starboard, thus increasing, rather than diminishing, the danger. The point is of special importance because this situation, if arising at all, is likely to come in the form of an emergency, as the lights of

sailing-vessels rarely show at the distance prescribed by the law, and frequently cannot be seen until close aboard. With twin-screws it is as easy to turn to one side as to the other.

It will be clear from what has been said in § II, concerning the relation of a fast steamer to a comparatively slow vessel crossing her track, that there is here a strong temptation to turn away from the slower vessel in the hope of getting across her bow; and no doubt there are situations in which this is the only thing to be done; but it is accompanied by serious risk and should be resorted to only in an extreme emergency. If it is attempted, *the speed must be maintained* at its maximum.

In the event of collision, it is a natural impulse for the vessel which has rammed the other to back out as quickly as possible. This is often the worst thing that could be done, since her bow must be for the moment closing more or less perfectly the hole that it has made.

Often, by keeping the engines of the ramming ship at dead slow ahead, it will be possible to save the other ship from filling and sinking long enough for the passengers and crew to make their escape—perhaps directly to the deck of the ramming ship.

Collision Mat (Plate **140**), supplied to each man-of-war other than capital ships, is a rectangular mat made of two or more thicknesses of canvas, quilted together, and fitted with lines from the corners, for getting the mat into position over the side wherever it may be needed, and holding it there. This calls for a hogging line, leading from the lower corner under the keel and up on the opposite side, and a distance line leading up to the rail on the side where the mat is placed; also for guy lines from the corners to stretch the mat forward and aft. To get the hogging line under the keel, it must be dipped by using a dip rope under the stem and passed aft to the point where it is needed. It was at one time the custom in the navy to carry a dip rope under the keel at all times, but this was found to chafe the line and to rub off the paint. It is now prohibited.

Hogging and distance lines are usually of chain or wire or both, and are always galvanized.

A collision mat properly placed may be a great help to a ship which is dead in the water, but its usefulness is greatly reduced if she attempts to steam at any speed. Its principal value is to

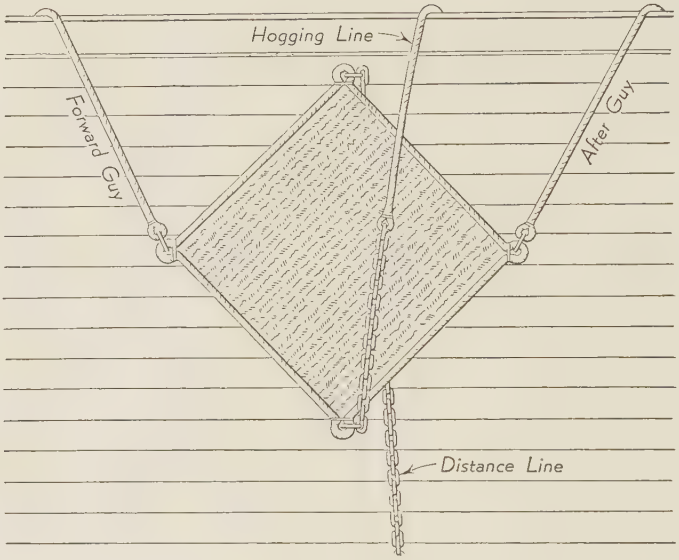


Fig. 1.—MAT ON DECK, READY TO GO OVER

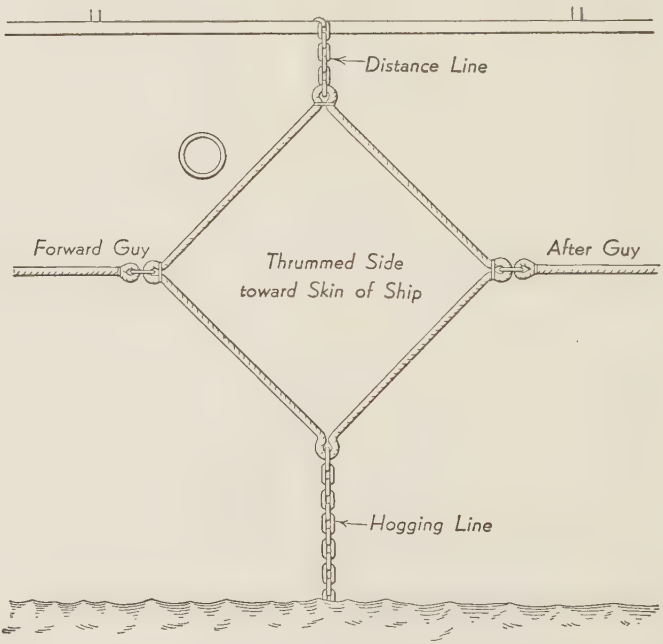


Fig. 2.—MAT IN PLACE

COLLISION MAT.

make other repairs possible—usually from the inside of the ship; though, of course, if any sort of structure is to be used on the outside, the mat may be kept in place *under* this and may thus continue to be efficient.

It might, for example, be practicable to construct a screen of planks to be hauled down over the outside of the mat and bound in place by lines around the ship and under the keel. If the hole is near the turn of the bilge, the planks might be seized together by short turns of rope passing through holes near the edges of the planks, these turns acting as hinges and making the screen sufficiently flexible to accommodate itself to the shape of the hull. A large piece of canvas—perhaps awning—might be put on the outside of all, and held in place by still other lines passed under the keel.

Having, by methods of this kind, checked the rush of water, it will usually be possible to build up a structure inside the ship which can be braced and caulked in such a way as to admit of proceeding to port.

If a water-tight compartment is to remain flooded, its bulkheads must be very securely shored from adjoining compartments.

CHAPTER XIV.

SHIP HANDLING.

The art of ship handling is developed in two distinct stages. The theoretical stage can be learned from this chapter. The practical stage can be obtained by experience only. It cannot be taught, it must be acquired.

There is certain information regarding the characteristics of each individual ship which must be known to the person handling her before attempting maneuvers of any kind. It includes data such as the following: twin or single screw, if the former, whether in-turning or out-turning screws, and, if the latter, whether a right- or a left-handed screw; draft of the ship; trim of the ship; type of motive power, since a reciprocating engine, Diesel, or electric drive installation has much more backing power than a turbine-driven vessel; and any special features affecting the maneuvering ability, such as slowness in reversing engines or being excessively cut away aft so that she spins rapidly on her heel. The effects of some of these features will be discussed in later sections.

Before maneuvering his ship, the ship handler must size up the situation and select a course of action. As his choice is based on many forces, the intensities of which cannot be judged accurately, the ship handler must be prepared for unexpected developments. To determine any divergence from the results expected, he must have a "seaman's eye," capable of quickly and accurately estimating angles and distances. If, in addition, he has the ability to make a quick decision, based upon sound judgment, he has the requisites of a good ship handler.

I. Definitions.

Right Rudder means the movement of the rudder to the right of the center line of the ship. The order "right rudder" requires the steering wheel to be moved to the right. The rudder then moves to the right, and this tends to move the ship's head to the right, when the ship is going ahead.

Left Rudder is the reverse of right rudder in wheel, rudder, and ship movement.

A **Right-handed Propeller**, when viewed from aft, turns clockwise while driving the ship ahead.

A **Left-handed Propeller** turns counter-clockwise under similar conditions.

The **Screw Current** is the current caused by the action of the propeller, which draws in the water more or less parallel to the propeller shaft, and discharges it as a rotary current in the opposite direction. As the propeller turns in its ahead direction this current comes from forward and is discharged aft. When the propeller is backing the current comes from aft and is discharged forward. The suction screw current is that portion of the screw current moving into the propeller, and the discharge screw current is that portion being driven out from the propeller. As the discharge current is formed along more compact lines than the suction current, it will exert a considerably greater pressure than the latter, but the effect of each of these forces on the action of the ship depends upon the portions of the ship upon which each impinges.

The **Sidewise Pressure** of the propeller creates an unbalanced force because the propeller blades pass through a different pressure depth at the lower portion of their arc than when passing through the upper portion of their arc. Due to this greater pressure depth at which the lower blades travel, there is a resultant force against the propeller (and therefore the ship) opposite to the direction in which the lower blades travel. As the lower blades in the right-handed screw ship will travel from right to left when turning in the ahead direction, this force always acts to the right and tends to swing the stern to starboard. With the screw backing, the direction of rotation, and hence the resultant force, is reversed, and this sidewise pressure tends to throw the stern to port.

The **Wake Current** is the body of water carried along with the ship as she moves through the water, and is caused by the friction between the skin of the ship and the water. It is a maximum at the surface and decreases with the depth. It becomes negligible at the keel.

The definitions given above must be thoroughly understood to analyze properly the various factors governing the action of a

ship under varying conditions of speed and rudder angle; and only by a complete knowledge of these factors may the behavior of a ship while maneuvering be successfully anticipated.

As the handling of a single-screw steamer is a great deal different from the handling of a twin-screw ship, the two will be treated separately.

II. Steering a Single-screw Ship.

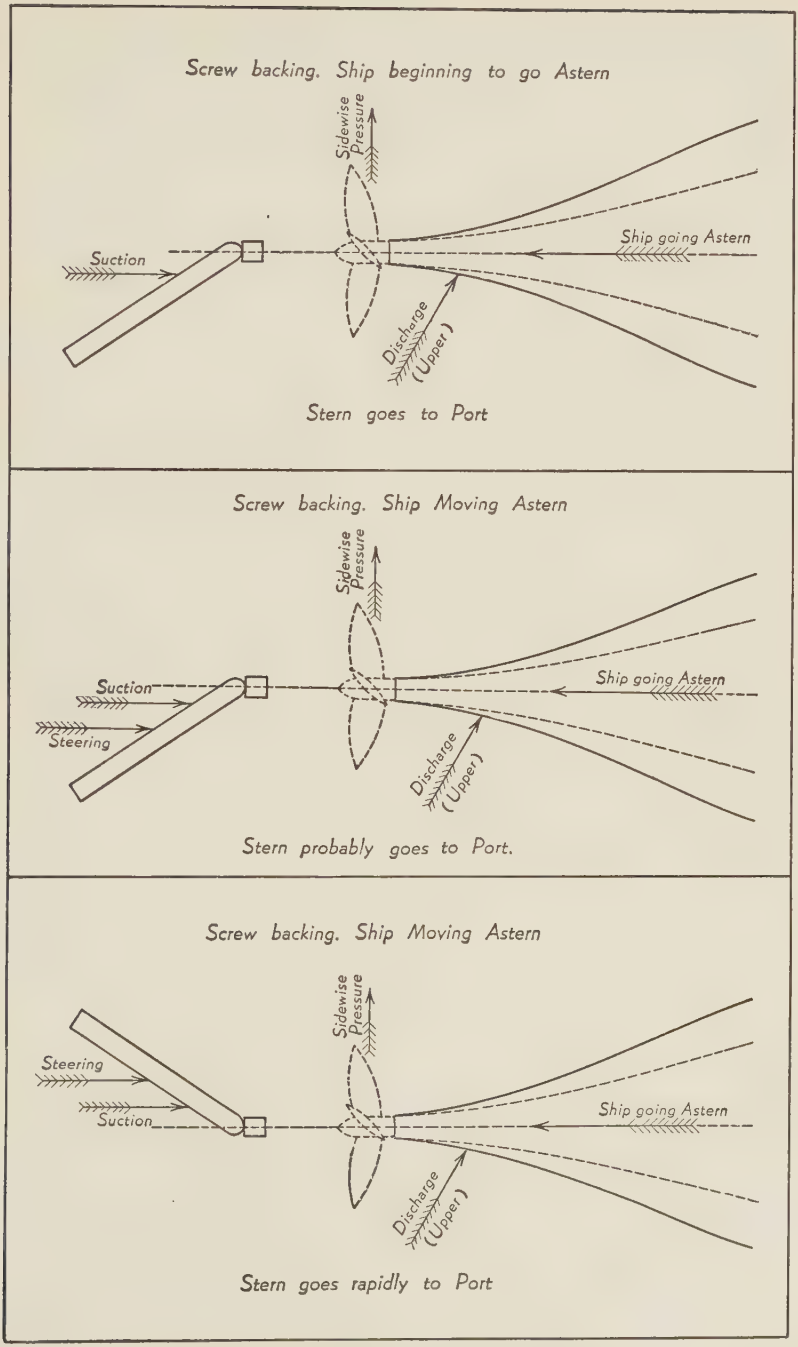
The elements which enter into the steering of a single-screw ship are so many, and their effects are so varied and conflicting, that any attempt at an exhaustive analysis of them would be altogether out of place in a work on practical seamanship. It is proposed to discuss briefly only the most important of them, and to explain such of their effects as enter practically into the handling of a ship. In this discussion it will be assumed, where not otherwise stated, that all conditions are normal and average; that is to say, that the ship is of medium size and draft; that she has no unusual features of design; that she draws more water aft than forward; that she has a right-handed propeller; and that her rudder is of the ordinary type and medium size. It will be assumed also, except where the contrary is stated, that the weather is calm.

The subject is discussed under the following heads:

1. Ship and screw going ahead.
2. Ship going astern, screw backing.
3. Ship going ahead, screw backing.
4. Ship going astern, screw going ahead.

Ship and Screw Going Ahead.

With considerable headway on, and with rudder amidships, the ship generally tends to go ahead in a straight line except as influenced by the wind and sea. The various minor effects of the wake current and the sidewise pressure of the propeller may be safely neglected here. When the rudder is put over, the water through which the ship is passing strikes the rudder and forces the stern in the opposite direction. The discharge screw current also strikes the rudder on the same side and works with the foregoing force to push the stern still farther over; hence, as



HANDLING SINGLE SCREW SHIP.

the result of these two forces, the bow swings in the direction in which the rudder has been thrown.

With the ship dead in the water and the rudder amidships, as the screw starts to turn, and until headway is gained, there is a tendency for the stern to swing to starboard due to the sidewise pressure of the propeller blades. As headway is gained, this effect is offset by the wake current. This wake current results in an increase in pressure against the upper blades, which tends to counteract that on the lower blades.

If, when dead in the water, the rudder is put over and the screw started, the thrust of the discharge current against the rudder causes the ship to swing normally, even though the direction of the rudder be to the right, as this force is much greater than the sidewise pressure of the propeller. As the ship gathers headway, her foward motion increases the rudder effect and the ship gradually reaches her maximum rate of turning.

Ship Going Astern, Screw Backing.

Under these conditions no single factor is predominant, as is the rudder effect with the ship and screw going ahead. Hence, the various forces must be analyzed to see which ones will govern the ship's movement.

The wake current has no influence, for it will be at the bow and therefore will exert no force on the propeller.

The sidewise pressure of the propeller will of course be opposite to that found when the screw is going ahead, and will, at all times be to port.

The steering effect of the rudder when the ship is going astern will tend to throw the stern in the direction in which the rudder is put; that is, right rudder tends to throw the stern to starboard.

The suction screw current will act on the rudder in the same manner as the ship movement through the water.

The discharge screw current is the complicating factor. It must be remembered that this is a rotary current, spiralling in a counter-clockwise direction as the screw is backing. Thus the current from the blades, as the blades pass through the upper right-hand arc of their circle, is thrown spirally against the starboard side of the stern fairly high up; that from the upper left-hand arc is thrown clear to port; that from the lower left-hand

arc is thrown against the port side of the stern, but well down; and that from the lower starboard arc also clears. This results in two forces, one against the starboard side and one against the port, but these do not balance. A consideration of normal ship construction will show that the hull is much nearer the upper than the lower blades; that the hull lines here are much fuller; that the angle with which this upper current strikes the hull is nearer to normal; and that much of the force of the lower current passes under the keel, due both to the fact of its striking so low and to the cut-away construction of the hull. Hence, the resultant of these forces exerted by the discharge screw current is against the starboard side aft.

When these varying forces are brought together, as in Plate **141,** the ship is influenced, as follows: The sidewise pressure of the screw and the discharge screw current always tend to force the stern to port. With the rudder to the right, only the force of the suction screw current tends to throw the stern to starboard. This is normally insufficient to overcome the other forces; hence, the stern will probably swing to port. With left rudder this swing of the stern to port is of course accentuated.

As sternway is gathered, the normal steering effect of the rudder increases. However, unless the speed of going astern becomes very high, even full right rudder will fail to overcome the constant force to port; hence, the common understanding among seamen that a single-screw ship always backs to port.

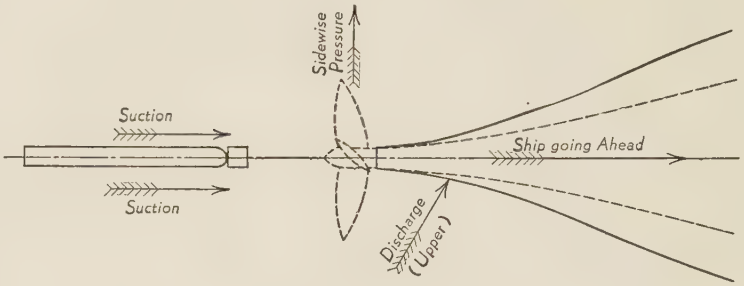
Ship Going Ahead, Screw Backing.

With the ship going ahead and the screw backing the sidewise pressure of the screw and the discharge screw current tend to force the stern to port.

With the rudder amidships, as in Plate **142**, it will be seen that both the steering effect of the rudder and the effect of the suction screw current are zero. Hence, as the only forces present tend to throw the stern to port, the stern will swing in that direction.

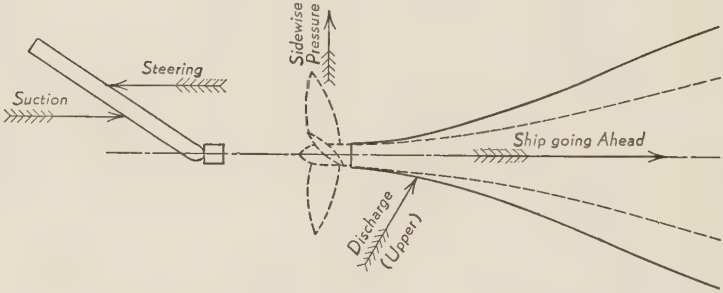
With the rudder left, the steering effect of the rudder will be to throw the stern to starboard. The suction current strikes the rudder from aft and tends to throw the stern to port. The actual result causing the ship to swing depends on the relative values of

Ship going Ahead. Screw Backing.



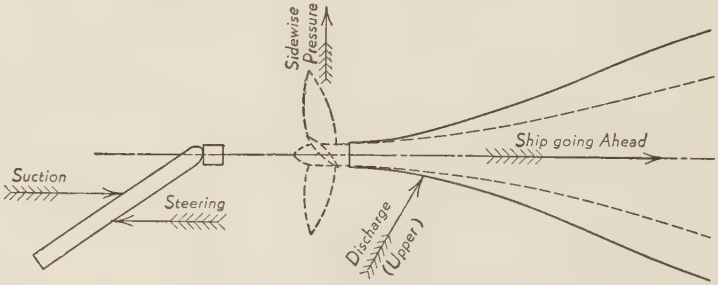
Stern goes to Port.

Ship going Ahead. Screw Backing.



Stern goes to Port. May go slightly to Starboard at First.

Ship going Ahead Screw Backing.



Stern will usually go to Port at first; and later it may go slightly to Starboard

HANDLING SINGLE SCREW SHIP.

the forces involved. With considerable headway on, the steering effect of the rudder will be sufficiently great to overcome all the other forces. In this case the ship's stern will swing to starboard at first. But, as the backing power of the screw slows the ship down, the direct steering effect of the rudder lessens, the swing of the ship slows, stops, and finally, the ship's stern swings off to port.

With the rudder right, the steering effect of the rudder is to throw the stern to port. The suction current tends to throw the stern to starboard. Thus, if the ship is moving at a fairly high speed, the stern swings rapidly to port, but the rate of swing will diminish, as the steering effect of the rudder is lost with the reduction in speed, and, as the suction current action on the rudder increases. This action of the suction current may cause the stern to swing somewhat to starboard before the ship comes to rest.

Ship Going Astern, Screw Going Ahead.

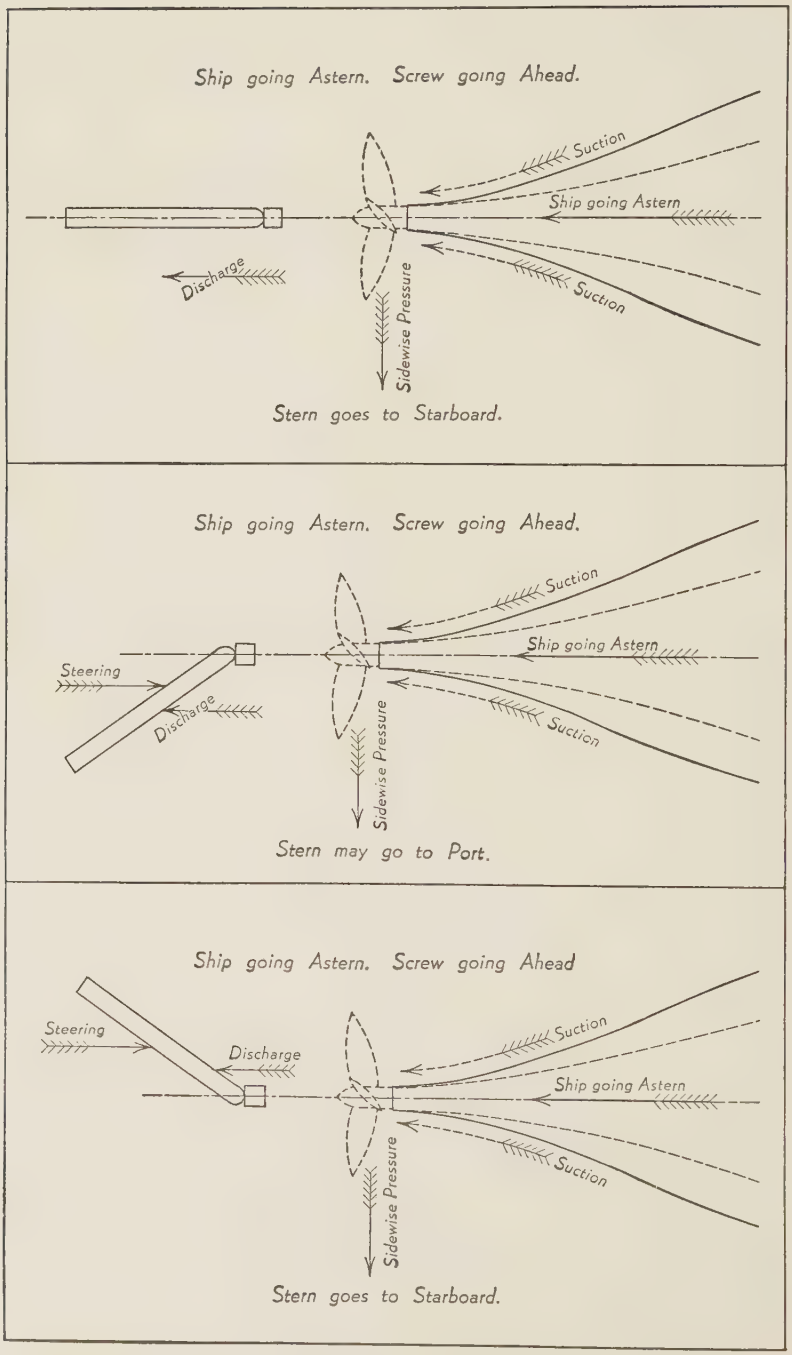
In this case, shown in Plate **143**, constant sidewise pressure of the blades tends at all times to throw the stern to starboard. The suction current follows the lines of the hull and exerts no effect.

With the rudder amidships, there is of course no steering effect from the sternway on the ship, or from the discharge current; hence, the ship's stern goes to starboard due to sidewise pressure.

With the rudder right its steering effect tends to force the stern to starboard, but the concentrated force of the discharge current is acting in the opposite direction. Here the resultant of these forces plus the sidewise pressure of the screw determine the direction of movement.

If the ship is making considerable sternway and full power is not being used in going ahead with the screw, it may be expected that the stern will swing to starboard. However, when only going slowly astern and with full speed ahead on the engine, the stern will swing to port.

With the rudder left the steering effect and discharge current effect reverse themselves from their previous action. Here again it is a question of relative values. With the ship going smartly astern the stern will probably swing to port, but the strong effect of the discharge current, plus the sidewise pressure of the blades,



HANDLING SINGLE SCREW SHIP.

will quickly overcome this and the stern will then swing to starboard.

In the foregoing paragraphs, dealing with the cases of a ship going ahead with screw backing and a ship going astern with screw going ahead, predictions of the ship's action are based on average conditions and full power on the screw. Should speed through the water be high and only half-power be used, some of the tendencies noted in the previous discussions may be reversed. It should also be remembered that a ship swinging carries considerable momentum, and will always tend to continue to swing in the direction in which she has started. This being the case, if conditions permit, always start the swing with the rudder before using the engine to change the direction of the ship's movement. In this manner the swing can be started in the proper direction, and the rudder and engine then used in the best possible manner to continue the swing. At all times in a single-screw ship remember that, when maneuvering, the position of the rudder depends on what the propeller is doing rather than on the direction of motion of the ship through the water. Finally, *Know Your Own Ship* and how she acts.

III. Steering a Twin-screw Vessel.

A twin-screw vessel has two propellers, one on either side of the center line. Generally they are out-turning; *i.e.*, the starboard one is right-handed and the port one left-handed.

A multiple-screw vessel normally has four propellers, two on a side, out-turning, and so controlled that those on a side go ahead or astern as a unit. As the action of a multiple-screw vessel is similar to that of a twin-screw vessel, only the latter will be discussed.

The steering of a twin-screw vessel is considerably simpler than that of the single-screw ship. It will be found that the strong tendency of the single-screw ship to back stern to port does not hold with the twin-screw vessel, and that the latter backs with equal facility in either direction, barring the effect of outside influences, such as wind, waves, and currents.

The various forces affecting the action of the single-screw ship are still present in the case of a twin-screw vessel, but in many

cases are considerably less, as the force from one screw is balanced by a similar but opposite force emanating from the other screw. In addition there is a new force due to the off-setting of the screws from the center line. It will readily be seen that with one screw going ahead and the other astern there results a turning moment tending to throw the *bow* to the side of the backing screw.

The steering of the twin-screw ship will be considered under the following headings:

1. Ship and Screws Going Ahead.
2. Ship Going Astern, Screws Backing.
3. Ship Going Ahead, Screws Backing.
4. Ship Going Astern, Screws Going Ahead.
5. One Screw Going Ahead, Other Backing.

Ship and Screws Going Ahead.

In this case, with rudder amidships and neglecting outside influences of wind and sea, the ship tends to go ahead in a straight line. The sidewise pressures of the propellers are equal and opposite in direction. As the shafts are offset equally from the center line, no turning moment results. The wake current effects on the screws are equal and opposite, and the suction and discharge screw currents exert equal and opposite effects.

When the rudder is put over, its normal steering effect is somewhat enhanced by the discharge current on that side, but not so much as in the case of the single-screw ship, since the screws are set off somewhat to the side and each screw is only handling half of the total power. As there are no unbalanced forces other than those acting on the rudder, the ship turns as easily to one side as the other.

Should one screw be stopped for any reason, the bow tends to swing to the side of the stopped screw. Here there are two forces acting; first, the sidewise pressure of the blades, and, second, the offset of the revolving screw which gives a moment forcing the bow in the opposite direction. Steering a straight course under such a condition is possible, as the tendency of the bow to swing is overcome by the rudder.

Ship Going Ahead, Screws Backing.

In this case the steering effect of the rudder, as modified by the suction screw current, is the only force tending to swing the ship from a straight line, all other forces being balanced out. Here the suction screw current opposes the rudder and reduces the total steering effect more and more, until, as headway is greatly reduced, steering control is lost. If only one screw is backing and the other is stopped, the sidewise pressure of the blades, the discharge screw current and the moment arm of the offset all tend to throw the stern away from the backing screw.

Ship Going Astern, Screws Backing.

With the rudder amidships, all forces tending to throw the ship off her course balance out, and she should move in a straight line. In the case of the single-screw ship the screw discharge current had a decided effect, but here the discharge current from one screw is balanced by that from the other, so the net effect is zero.

When the rudder is put over, the suction screw current increases the normal rudder steering effect, and the ship swings to either side with equal ease.

With one screw stopped, the *stern* swings to the side of the stopped screw because of the moment arm, the sidewise pressure of the blades, and the discharge screw current. This swing may be stopped by use of the rudder, as its steering effect is augmented by the suction screw current.

Ship Going Astern, Screws Going Ahead.

When both screws are going ahead there is no unbalanced force except that from the rudder, which is opposed by the discharge screw current. However, as the discharge screw current is concentrated, it overcomes the steering effect of the rudder very quickly, and steering control is lost until headway is gained. With only one screw going ahead, and the other stopped, the sidewise pressure of the blades and the moment arm of the offset tend to throw the stern toward the revolving screw.

One Screw Going Ahead, Other Screw Backing.

In this case there is a maximum effect from the moment arm due to the shafts being offset from the center line. In a ship of wide beam in comparison to length this effect is naturally more pronounced than in a vessel of finer lines, as the engines will be spaced much farther apart. The effect of this moment arm is, of course, to throw the stern away from the backing screw regardless of the direction of movement of the ship in the water. The sidewise pressure of the blades on both screws helps this effect, as does the discharge current from the backing screw. As this maneuver is used only when a turn of small diameter is desired, it follows that the rudder should be thrown in the direction required to further assist the turn. For example: when going ahead on both engines and it is desired to swing to starboard, stop and back the starboard engine and put on hard right rudder. Or, with sternway on and desiring to swing the stern to port, go ahead on the port engine, back on the starboard engine, and use full left rudder. Note that in these two cases, although the swing of the bow is to starboard and the engines are used in the same manner, the rudder is reversed. When maneuvering a twin-screw ship, the rudder is used in relation to the direction of motion of the ship through the water rather than in relation to the direction of rotation of the propellers.

With no way on and with engines opposed, the swing of the bow is to the side of the backing screw. However, as a ship can be driven ahead with less power than she can be driven astern, it will be found that with both engines making the same number of turns she will gradually forge ahead as she swings. To turn her without making way ahead or astern, the speed of her engines must be adjusted with the backing screw going faster than the other until she turns on her heel. The rudder must be left amidships, as in any other position it will tend to oppose the turn. The difference of engine speeds to turn a ship on her heel will vary for different ships, and can only be learned by handling the particular ship concerned. It should also be noted that in the case of vessels of extremely fine lines, such as a destroyer, the turning moment from the opposed screws is generally insufficient to turn her when dead in the water, but by first giving her a little headway and using the rudder to start the

swing, she can then be kept swinging by use of the screws as above.

Turning.

Before considering the track actually followed by a ship during a turn, certain terms used must be defined. By referring to Plate **144,** showing turning circles for the *U. S. S. New Mexico,* and to Plate **145,** they may be easily understood:

(*a*) *Turning Circle.* The path followed by the center of gravity of a ship when making a complete turn of over 360°.

(*b*) *Advance.* The distance gained toward the direction of the original course from the point where the rudder is put over.

(*c*) *Transfer.* The distance gained at right angles to the original course.

(*d*) *Tactical Diameter.* The distance gained to the right or left of the original course when a turn of 180° has been completed with a constant rudder angle.

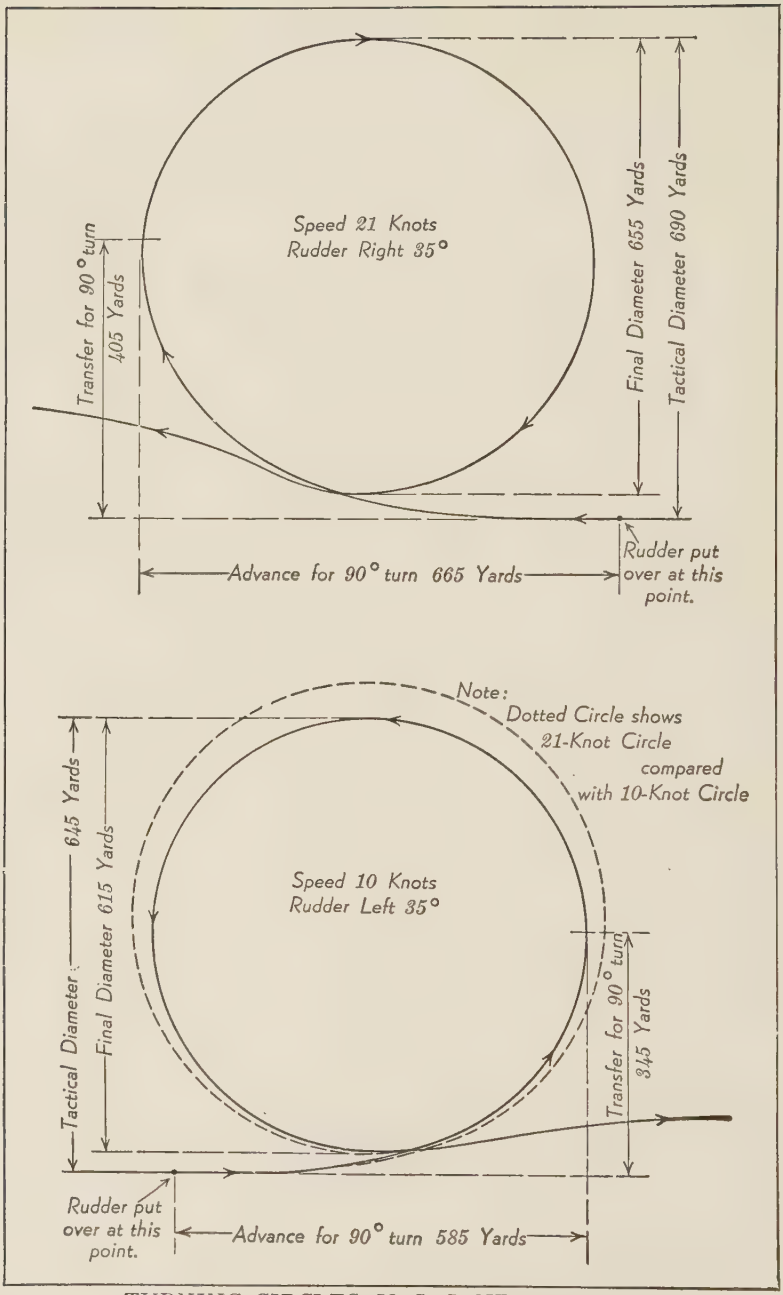
(*e*) *Final Diameter.* The distance perpendicular to the original course between the point where 180° and 360° of the turn has been completed. Should the ship continue to turn indefinitely she will continue to turn in a circle of this diameter.

(*f*) *Drift Angle.* The angle at any point on the turning circle between the tangent to the turning circle at that point and the keel line of the vessel.

(*g*) *Kick.* The swirl of water toward the inside of the turn when the rudder is put over to begin the turn.

(*h*) *Pivoting Point.* That point of the ship about which the ship turns when the rudder is put over. The position of this point varies with different ships. Normally it will be from one-fourth to one-third of the ship's length from the bow, but its location will change somewhat under various load conditions of the ship.

When the rudder is put over at the start of the turn, the stern will first move away from the direction of the turn. The whole ship then "crabs" off in the same direction as it slowly begins to turn. Due to her momentum along her original course, the ship will range ahead along that course for two or three lengths before beginning to gain ground in the desired direction. After about 90° of the turn is completed, the drift angle becomes constant,



TURNING CIRCLES, U. S. S. NEW MEXICO.

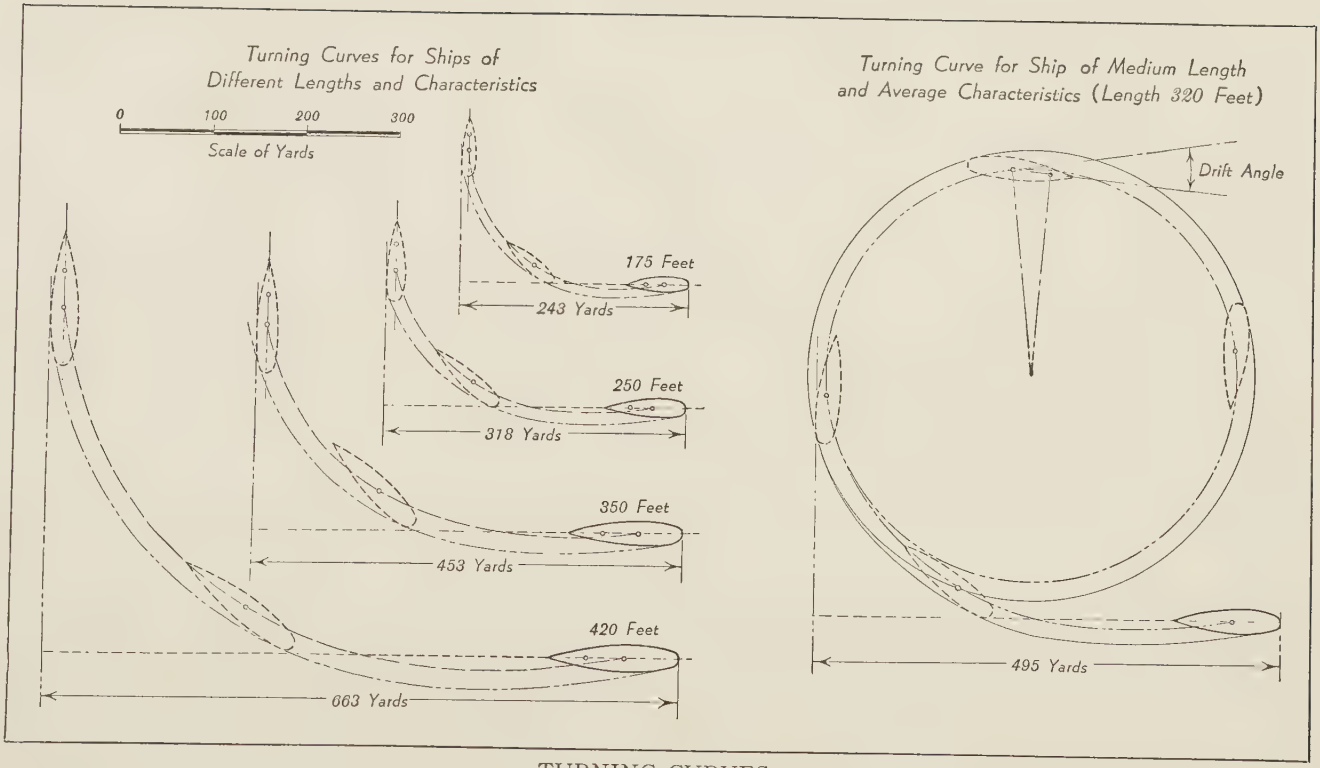
and the turn continues at a constant rate. It will easily be seen from the diagrams that it is the kick followed by the crabbing to one side that causes the difference between the tactical and the final diameter.

During a turn, because of the fact that the ship is to a considerable degree being forced sidewise through the water rather than straight ahead along her normal structural lines, there is a large loss of speed, this loss amounting to as much as 40 per cent. This explains why, when cruising in column, one rapidly overtakes the ship ahead when she gets well into her turn, and why she again pulls ahead to the proper distance as she straightens out and one's own turn is well started.

Experiment shows that the speed at which a vessel makes a turn has very little effect on the diameter of the turning circle. However, since the distance to be covered remains constant, the speed does effect the *time* necessary to make the turn. The amount of rudder used does effect the diameter, but experiment shows that the use of more than 36° of rudder actually increases the diameter of the turning circle as well as slowing the vessel down. For this reason, naval ships are generally designed with a maximum rudder angle of 35°. As might be expected, anything that will increase the forces causing the stern to swing will also cause a decrease in the diameter of the turning circle. Therefore, when a sharp turn is desired of a twin-screw vessel, the inboard screw is backed full speed and the outboard screw is driven at full ahead, thus getting the maximum advantage from their turning moment.

IV. Rudder and Engine Orders.

It is apparent that once the officer conning the ship has decided upon a particular maneuver, it cannot be successfully carried out unless his orders concerning the movement of the rudder and engines are understood and promptly carried out. For this reason a standard phraseology governing orders to steersmen and engine room telegraph operators (annunciator men) is required and this phraseology and no other must be used.



TURNING CURVES.

Orders to the Wheel.

Orders to the wheel and engine room telegraph must be given in a clear, firm, and audible voice, and in standard phraseology.

In giving many of the commands to the steersman, the first word is one of direction, and the second, the amount of rudder:

"Right (left) standard rudder!" Standard rudder is that amount of rudder used when making a turn with standard tactical diameter. This rudder angle is determined by trial for each type of ship, and may differ among ships of the same type.

"Right (left) 5 (10, etc.) degrees rudder!"

"Right (left) rudder!"

"Ease the rudder!" This order is given when the ship is swinging too rapidly or when a battleship is about 20° from the new course.

"Rudder amidships!" This order in a battleship making a turn is given when about 10° from the new course. Practice will determine the proper point at which it should be given for small changes of course.

"Meet her!" This order requires that opposite rudder of about 10° be given a ship in order to prevent her swinging past the new course. In a battleship this is given when about 5° from the course.

"Steady" or "Steady as you go!" These are given to the steersman when it is desired to keep her on the heading she has at that instant.

"Shift the rudder!" This is an order to change from left to right rudder or *vice versa.*

"Nothing to the right (left)!" This is given when the course to be made good is a shade off the course set, and, therefore, all small variations in steering must be kept to the left (right) of the compass course. It is frequently used to avoid obstructions, buoys, or passing ships.

"Very well" is given to the steersman as an acknowledgment of a report. The expressions "All right," "O.K." or "Aye Aye" are not correct and should not be used.

All orders to the steersman as to the course must refer to the compass by which he is steering at the time and must be in the

form "Course, Zero Zero Five." The steersman is not concerned with whether the course is true or magnetic and must never be required to apply corrections, deviations, or variations.

The steersman must repeat all orders exactly as given and report when they have been carried out. When he is relieved, he must report the fact to the officer of the deck and report the course being steered. The officer of the deck should check the compass course upon assuming a new course, and frequently thereafter.

Orders to the Engines.

Orders to the engine telegraphs are in three parts:

(*a*) The first part designates the engine, as "Starboard (port) engine" or "All engines." This puts the annunciator man on the alert.

(*b*) The second part of the command gives the direction in which the engine telegraph is to be moved, as "Ahead" or "Back."

(*c*) The third part of the command gives the speed at which the engine is to be moved.

Thus: "All engines, ahead, full"; "Port engine, back, two-thirds"; "Starboard engine, ahead, standard!"

Every order to the engine telegraphs must be repeated word for word by the annunciator man. When the engine room has acknowledged the order by the repeat back system on the telegraph and the shaft revolution indicators show the engines are in the process of carrying out the order, the annunciator man should then report what the engine is doing. Thus, upon the order from the officer of the deck, "Starboard engine, back, one-third," the man on the telegraph repeats, "Starboard engine, back, one-third, Sir." At the same time he rings up "back one-third" on the starboard telegraph. When this is repeated back from the engine room on his telegraph, and the engine begins to back he reports, "Starboard engine backing one-third, Sir."

In most ships bell pulls provide for one-way communication to each engine from the bridge for use in case the telegraphs break down. The signals used for handling the engines vary somewhat on different ships, so are not given here, but a brass plate will be found mounted near the bell pull giving the proper signals to use. In addition there is always a voice tube for emergencies, and on the larger ships a telephone between the bridge and the engine room is always manned and all orders are repeated over it.

Despite all these precautions, standard phraseology, repeating back of orders, reporting of compliance, and standby system of communication, an error will occur occasionally. The officer of the deck must be alert to check the execution of each order by such means as the rudder indicator and the shaft revolution indicators in order to catch any such errors before serious damage results.

V. Handling a Ship.

In actual practice there are a number of characteristics, forces, and influences which enter into the problem of ship handling. The first and foremost of these is the design of the ship. It is important that every ship handler know his vessel.

A large part of the resistance to a turn is caused by the ship's deadwood. If this is reduced or removed, her tactical diameter is reduced, but she is harder to keep on a steady course in a sea and the wind will have a different effect on her. Also, heavy weights such as turrets at the ends of the ship have great rotational inertia, causing her to act like a flywheel; that is, difficult to start turning, and once started, difficult to stop.

The effect of the wind will vary with the design of the ship. Freeboard and superstructure act as a sail area and must be so considered. A high bow, as on a ship high out of the water, or on a destroyer, becomes a headsail. As the drift to leeward is opposed by the underwater body, the shape and draft of this must be considered. If a ship is down by the stern, this, plus the drag of the propellers, causes her to pivot nearer the stern. The bow usually falls off, the rapidity of which is dependent on the type of the ship and the force of the wind. To keep the ship on her course a certain amount of rudder is required.

In going astern, the sterns of the great majority of ships back into the wind. Whenever turning around in a confined space, this tendency can be utilized. Thus, with the wind on one bow, the turn should be made away from the wind, and the engines reversed when the wind is well abaft the beam, thereby backing the stern into the wind.

Another influence on the steering of a vessel is the condition and relative direction of the sea. The general tendency is to cause her to find the trough. With much wind, which usually blows from the same direction as the sea, some ships with no

steerageway will fall off until the sea is quartering. To keep her head up, steerageway must be maintained. If the vessel is backed, the stern usually backs up into the sea. When current and wind are present, the vessel reacts more to the current if heavily laden and has low freeboard. It reacts more to the wind if light.

In shallow water a vessel is sluggish in answering her rudder and may sheer to one side. Slow speed, watchfulness, and an anchor in readiness for letting go are the best safeguards. High speeds in shallow water are accomplished with a great waste of power, which goes into forming large waves, and these in turn are apt to be destructive to shipping and to waterfront facilities.

The use of an anchor as an additional and controllable influence in shallow water should be considered. It can be used for snubbing, in which case the anchor with a very short scope of chain is dropped under foot, thus slowing the vessel, while allowing greater power, with increased steering effect, to be used.

In the study of ship handling one must always bear in mind that there are more solutions than one to a problem, and often two good seamen will solve it in different, but satisfactory, ways.

The following are but a few cases of ship handling which may be considered basic.

Working in a Narrow Channel.

In turning in a narrow channel with a single-screw ship, the vessel should cast to starboard. Before reversing the engine, the ship should gather headway and then be swung to starboard by using the rudder. Next, the engine is backed down full, which will tend to swing the bow to starboard and the stern to port. This is followed by shifting to left full rudder. When far enough astern, the engines are put ahead full and the rudder is shifted to right full rudder. Plenty of power gives a greater screw current effect from the propeller, thus tending to pivot the ship; but, when the ship begins to move, this power must be reduced to prevent excessive speed.

A twin-screw vessel swings equally well to either side. To turn in a limited space the inboard engine of a ship is stopped and the rudder put hard over. After she starts to swing, the

inboard engine is reversed and its speed adjusted so that the ship will continue to forge ahead with steerageway.

Should there be a wind, it should be used to advantage. In going ahead the turn is made somewhat easier away from the wind and in backing the stern tends to back into the wind.

The current may be used by putting the bow into an eddy, counter current, or slack water near the bank. The stern will thus be swept around. Where these do not exist, an anchor may be used.

When attempting to make a sharp bend in a narrow channel, great difficulty will be experienced when bucking the current. Referring to Fig. 1, Plate **146**, it will be seen that as the bow clears the bend the full force of the current strikes the bow, producing a rank sheer to port. As she then nears the far bank as in Fig. 2, note that the backwater strikes her port quarter, thus tending to increase the sheer with consequent danger of grounding. Figures 3 and 4 show the result of a similar turn with the current. Here everything is favorable. As she clears the bend the current strikes her port bow, forcing her to turn, and as the turn progresses, the reverse current continues on her port bow and the main current strikes the starboard quarter, further assisting the turn. Thus, regardless of rudder, the ship will have difficulty in keeping from making a successful turn.

Two ships should not attempt to pass in a narrow bend. However, if forced by circumstances to do so, and if the Rules of the Road permit, the ship heading with the current should hug the inside of the turn, and the ship bucking the current should take the outside as shown in Fig. 5. This merely carries out the results seen in Figs. 1 to 4. If the two ships attempt to reverse their positions as in Fig. 6, that is, the one coming with the current taking the outside, a collision will probably result. While the ship heading with the current can negotiate the turn successfully on the outside, the one heading upstream will take a sharp sheer as in Figs. 1 and 2, with danger of a collision.

In a straight narrow channel, and particularly so if the draft of the vessel is nearly equal to the depth of the water, a vessel will be set off the nearer bank. This is called "bank cushion." The wedge of water between the bow and the nearer bank builds up to a higher level than that on the other side and the bow is forced sharply out. The suction of the screw nearer the bank

Fig. 1.

Fig. 3.

Fig. 2.

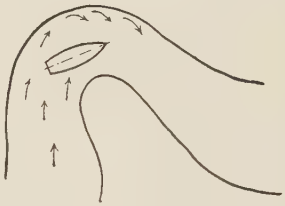


Fig 4

Fig. 5.

Fig. 6.

TURNING A SHARP BEND WITH AND AGAINST CURRENT.

lowers the level of the water between the quarter and the bank. This draws the stern in closer. This is called "bank suction." Bank cushion and bank suction together result in an alarming sheer toward the opposite bank. The rudder usually is unable to overcome this sheer, and the ship will ram the other bank unless other steps are taken to prevent it. If a single-screw ship, traveling at a low rate of speed and with her starboard side nearer the bank, takes a sheer to port, she can usually be brought under control by backing full with left full rudder. A twin-screw vessel, proceeding slowly, has a fair chance to recover by going ahead full on the outboard screw stopping or backing the inboard screw and putting the rudder hard over toward the nearer bank. If the vessel crosses mid-channel, the anchor which is nearer the bank from which the vessel is sheering should be dropped and snubbed and the other anchor dropped and snubbed shortly thereafter. Both engines are reversed as the first anchor is dropped.

In a narrow channel, it is best to proceed at a very low speed and to keep to the middle of the channel. When meeting and passing another vessel near the center of the channel there will be a tendency when the bows are abreast for the ships to be forced apart by the water between them. As they pass abeam, the rudders should be placed toward the other ship. The sterns are thus swung clear of each other. When the sterns draw near to each other, the suction between the ships will tend to draw the sterns together and thus straighten the ships out. As these forces all tend to keep the ships clear of each other and the banks, two vessels meeting and passing should pass close to each other near the middle of the channel. The ship must not approach nearer the bank than is necessary and then only when going at a very low speed.

To overtake a vessel in a narrow channel is very dangerous, because the suction created by the vessels' propellers tends to draw them into collision.

VI. Mooring Lines.

Prior to the study of docking a vessel, the names of the lines and their uses in mooring ship should be understood.

In mooring to a dock a line run through the bull-nose or chock in the eyes of the ship is known as a "bow line," and a corre-

sponding one from the stern chock is known as a "stern line." Usually they lead well up the dock and tend to reduce the fore and aft motion of a ship when moored.

All other lines are named by a combination of words, as follows:

1. *Forward* or *after,* which gives the direction in which the line tends from the ship.

2. *Bow, waist,* and *quarter,* which gives the part of the vessel from which the line is run.

3. *Breast* or *spring,* which gives the use of the line. Thus: forward bow spring, after bow spring, bow breast, forward quarter spring, after quarter spring, quarter breast, waist breast, etc.

A breast leads at right angles to the ship's keel and prevents a ship from moving athwartship.

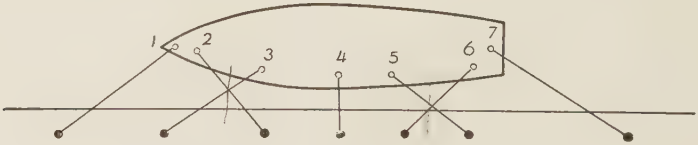
A spring leads forward or aft and prevents a vessel from moving aft or forward, respectively.

If only a breast is out and the ship is moving forward or aft, the ship will be sprung into the dock, and therefore this breast becomes a spring.

Handling of Lines.

Lines properly handled are the greatest assistance in making, or clearing, a dock. To prevent confusion and to add to the efficiency of the line handling, lines are numbered from forward aft, according to the position where they are secured on board the ship.

The names of the lines are seldom used in handling, as the numbers are shorter and more precise. The names for the lines are as follows:



1. Bow line 2. After bow spring 3. Forward bow spring 4. Waist breast 5. After quarter spring 6. Forward quarter spring 7. Stern line

A ship may use fewer or more lines as necessary, in which case the numbers are changed accordingly. Prior to a ship coming

alongside, the required lines with eye splices in the ends to go ashore should be available, led through the correct chocks, and up and over the life lines. Heaving lines should be made fast near the eye splice and not at the end of the bight, where it will become jammed when the eye is placed over the bollard. Heaving lines should be passed as soon as possible, though the heavy lines, the bights of which are necessarily hard to handle, may be run later when the vessel is further up the dock.

As a large ship works her way up the dock or into the slip, the lines should be fleeted up the dock in short fleets; thus, keeping them in position for use.

If two bights or eye splices are to be placed over the same bollard, the second one must be led up and through the eye of the first and then placed over the bollard. This makes it possible for either to be cast off independently of the other.

If the ship is lying dead in the water abreast of a dock, as in Fig. 1, Plate **147**, and has a bow breast leading to the dock, hauling on this line will turn the bow in, and will also throw the stern out, the ship pivoting about the center of gravity. It should be noted, however, that the stern does not go out as much as the bow comes in; for, since the ship is not held rigidly at the pivoting point, the mass as a whole will respond to the force acting on the bow, and the resultant motion will be like that shown in the figure.

If in the above case the stern is held by a line to the dock, as in Fig. 2, the pivot is transferred to the stern and the whole length of the ship comes in, when the bow breast is hove in. This requires much greater effort than to turn the ship about her natural pivoting point as in Fig. 1.

If the bow and quarter breasts are hauled on at the same time, the ship may be breasted in bodily, but at an even greater expenditure of work than in the preceding case.

If the ship has way, either ahead or astern, her momentum enters into the problem of her behavior.

In Fig. 3, with engines stopped and rudder amidships, the steamer is moving forward parallel to the face of the dock and the after quarter spring AK is taut. The motion of the ship will be that resulting from her momentum along the orginal course and the tension along AK. The tension on AK may be resolved into two components. One retards the ship along the

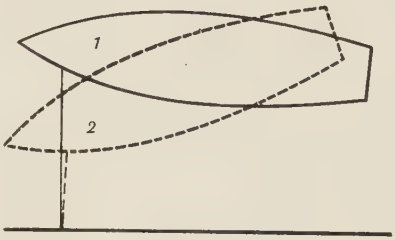


Fig. 1

Fig. 2

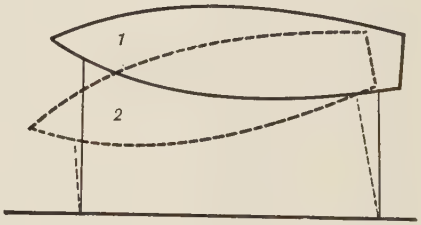


Fig. 3

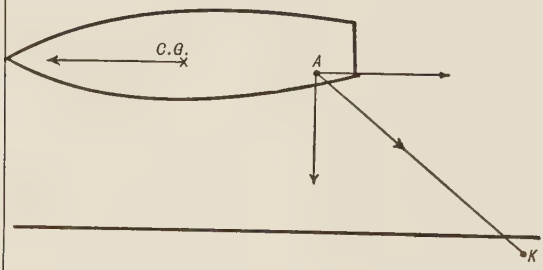
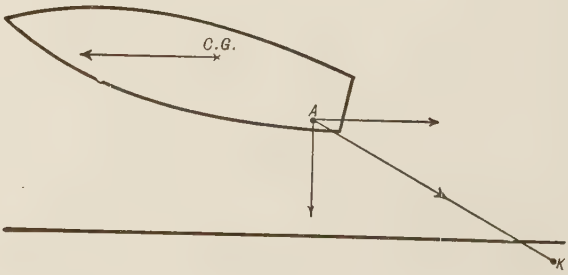


Fig. 4



HANDLING STEAMERS AROUND A DOCK.

line of her original course, and thus directly opposes the momentum, and the other hauls her toward the dock and tends at the same time to turn her about the center of gravity, thus drawing the stern in and throwing the bow out. It is important to note, however, that the momentum, which is concentrated at the center of gravity, forward of the pivot (*A*), opposes the turning and tends to keep the ship parallel. Thus, as a matter of fact, the ship does not turn much, but comes in nearly parallel to the dock as shown in Fig. 4.

If the vessel in Fig. 3 is moving ahead, but with an after spring from the bow instead of from the quarter, the forces acting are similar to those in figure 4, but with an important difference. The momentum acts to increase the turning effect of the spring, instead of opposing it. This will become clear if figures 1 and 4 are compared. The result of this difference is that the bow of a ship, moving ahead on an after bow spring, turns sharply in toward the dock; whereas, in the other case the stern is turned in very little, if at all, by an after quarter spring.

If the ship is moving astern, instead of ahead, the conditions are reversed, in that a forward quarter spring will turn the stern sharply, while a forward bow spring has little turning effect.

The vessel in Figs. 3 and 4 puts her rudder to port to throw her head in. Since the steering effect of the rudder is chiefly a matter of moving the stern of the ship, and since the stern cannot be thrown off to starboard because it is held by the spring, it follows that left rudder can here have comparatively little turning effect. Right rudder, on the other hand, will help materially to throw the stern in.

If in Figs. 1 and 2, the rudder is put to port, it will throw the stern off and greatly increase the rapidity with which the bow turns in. If put to starboard, it will oppose the turning, but not enough to overcome it.

If in any case the line is made fast at the center of gravity and the ship is working ahead, the ship will spring in bodily; and her heading can be controlled by putting the rudder over, which throws the stern to either side, as desired. The ship swings under the influence of the rudder, while coming bodily in on the spring.

Orders to the Men at the Lines.

"Slack Away" or *"Slack Off!"* Pay out the line, allowing it to form an easy bight.

"Take a Strain!" Put the line under tension.

"Take in the Slack!" Heave in on the line, but do not take a strain.

"Ease It," "Ease Away," or *"Ease Off!"* Pay out enough to remove most of the strain.

"Check It," "Check Number Three!" Hold the line, but render it enough when necessary so that it will not part.

"Hold It!" Take sufficient turns that the line will not give.

"Double Up and Secure!" Run any additional lines and double all of them, as necessary.

"Single Up!" Take in all additional lines, leaving as few as are absolutely necessary to hold the ship temporarily.

"Stand By Your Lines!" Man the lines, ready to cast off.

"Cast Off All Lines!" Let go all lines.

VII. Going Alongside—No Set on or off the Wharf.

A single-screw (right-hand) vessel can be easily handled in making a wharf to port, as the stern will go in toward the wharf when backing the screw.

For a single-screw ship making a wharf to starboard, the port anchor is used for snubbing. When in position the engine is reversed. The use of the anchor will reduce the speed of the approach and will counteract the tendency of the bow to go into the dock when the engine goes astern. Also, a quarter breast or spring can be used to hold the stern in and thereby keep the bow out. When dead in the water, starboard side to the wharf, the stern can be swung in by using full left rudder and ahead two-thirds on the engine. The engine must be stopped before building up any headway. An after quarter spring will assist.

A twin-screw vessel handles equally well to either side. With the proper lines and fenders ready, and the outboard anchor ready for letting go, the wharf is approached at an angle of ten to twenty degrees at minimum speed. When approaching the

wharf, various fixed objects on or in the vicinity of the wharf may be used as temporary ranges to ascertain whether or not there is any set. The ship is headed for a definite point where it is desired for the bridge to be when the ship is secured. The engines are stopped and when the bow is fairly close to the wharf, the ship is paralleled by using the rudder, and by backing down on the outboard engine, thus stopping the ship's headway at the proper point alongside the wharf.

Going Alongside—Being Set onto Pier.

If, in the approach, it is seen by the use of ranges as in the preceding paragraph that the ship is being set onto the pier, the ship must be stopped and, with half a beam's width of open water between, brought parallel to the pier. The current will set the vessel on. A close landing under these conditions is dangerous, if the set is underestimated. Therefore, plenty of room for any error in judgment must be allowed. Should this set be unexpected and the ship too far in, the relative value of the set can be diminished by going ahead faster and making the landing in a shorter time; thus, decreasing the time during which the set is effective. This takes good judgment and instantaneous decision.

Should the set be so strong as to damage the vessel or the pier when they come together, the ship's head should be canted outward when the ship is abeam of the dock, except in the case of a single-screw vessel making a pier to port. When the ship is almost stopped and is close upon the pier, a powerful wash from the propeller (inboard, if a twin-screw) backing, will straighten the vessel out, stop her headway, and create a cushion of water between her and the pier.

Going Alongside a Pier—Being Set Off.

Should it be seen that the vessel is being set off the pier, the ship's head is pointed well up into the pier and the approach is made with more speed. The bow lines are gotten out, and when close to the pier, the rudder is put away from the pier. For a

single-screw vessel, port side to, the landing is easily made by backing down on the screw. For a single-screw vessel making a pier to starboard, the approach is made by snubbing the port anchor as previously described. Instead of snubbing the port anchor, a starboard quarter breast can be used to hold in the stern, as the ship forges slowly ahead on it.

In a twin-screw vessel, the outboard engine is backed full.

Going Alongside—Current from Ahead.

When a current is running parallel to a wharf, the ship should be headed into the current and then brought alongside. Slack water is the most favorable condition; yet the current, if not too great, can be used and the berthing accomplished without trouble, except in the case of the largest vessels. With current from ahead a vessel can use more speed through the water without increasing its speed relative to the pier; therefore, the ship will have better rudder control with the same degree of safety.

The ship, making little headway along the face of the wharf, is brought in fairly close and parallel. The vessel must not be canted in, as she might come in too fast and cause damage. A forward bow spring is sent well ahead and up the pier.

When in position relative to the pier, all forward motion relative thereto is stopped and the vessel is slowly dropped back on the spring. The amount of tension on this spring determines the rapidity with which the ship drifts in to the pier. The rudder may be used to swing the stern.

Should the current be very strong the ship should go a little way above the wharf and drop the outboard anchor. A forward bow spring should be run ashore. By veering chain and holding the spring the ship will swing slowly in toward the wharf. By using the rudder and adjusting the strain on the anchor chain, perfect control can be maintained. When alongside a bow breast and forward quarter spring are got out as soon as possible.

Going Alongside—Current from Astern.

Making a pier with a fair current is dangerous and should be avoided when possible. If there is swinging room, and if other reasons do not forbid, much time and fuel will be saved and

danger avoided by dropping an anchor, swinging with the tide, and making the pier as previously described with the current from ahead. If this is not practicable, tugs should be used, if available. If a tug is not available, the approach should be made as slowly as possible and as near to the pier as is safe. When about in position, the bow is canted out a few degrees from the wharf. An after quarter spring is got out as soon as possible and the engines backed to keep from parting the line. Backing on the inboard engine of a twin-screw ship forces more water between the pier and the ship, thus cushioning her as she comes in.

Clearing a Pier—No Wind—No Current.

Clearing a pier is less difficult than making a pier. The first step is to slack all lines carefully and observe the effect. If the ship does not drift out, it will be necessary to force the stern away from the pier.

In a single-screw ship with the starboard side to the wharf the engine is backed. This swings the stern rapidly to port. If the bow is forced into the pier, right rudder is used to clear it, as the ship goes astern. When the stern is about fifty yards out, the bow will be pointed in toward the pier. A quarter breast, which becomes a spring as the ship continues to go slowly astern, is now held. This will bring the bow out. When pointed fair, the ship casts off and goes out ahead.

If the port side is to the pier, an after bow spring is used, as the ship goes ahead slowly on it. Left full rudder throws the stern well out. The ship is cast off and backed down slowly with right full rudder, until clear. As the stern will gradually turn in toward the pier, it will be necessary to stop when parallel to the pier and several beams' width out from it. The vessel now goes ahead with right full rudder and the bow falls off as required.

In a twin-screw vessel, all lines are let go and the inboard engine is backed, which will force her stern clear by the screw discharge current, particularly so if the pier is of a solid wall type. The bow will swing toward the pier as the stern swings out. Fenders should be available and any scraping of the bow along the pier should be avoided. This is done by backing

also on the outboard engine and thus stopping the swing just before the bow touches. The officer conning should glance aft and watch his after mast against the shore line to note any tendency of his ship to start swinging either way. He should use the engines for steering until sufficient sternway is reached, when the rudder should be used. The distance between the pier and the bow should be noted and the rate of turn regulated to prevent touching. The inboard screw discharge current when it reaches the bow tends to keep the bow off.

Clearing a Pier—Being Set On.

This is a difficult situation. To go out ahead without the use of tugs or an outlying anchor is dangerous. The ship must be taken out astern.

A single-screw ship with her starboard side to the pier should go ahead on an after bow spring, and when the stern is well out, cast off and go astern full. If she is port side to, it is advisable to wait for a change in conditions.

A twin-screw vessel first should go ahead on the outboard engine and on an after bow spring. This will throw the stern out against the set. The ship should then back immediately with plenty of power on the inboard engine and cast off the spring. The wash of the inboard engine will tend to keep her off. The outboard engine must now be backed to get the ship clear as soon as possible.

Clearing a Pier—Being Set Off.

If, when all lines are slacked, the ship tends to drift out, the clearing of the pier is very simple. Continued slacking away on the lines will ease the ship off the pier. All lines are then cast off and the ship can proceed.

Clearing the Wharf—Current from Ahead.

With a forward quarter spring a strain should be taken by easing off all other lines. The stern will come in and the bow will go out where it will catch more of the current. While going ahead very slowly to keep the stern and the propellers away from

the wharf, the bow will continue to swing. When far enough around, the ship may cast off all lines and proceed.

Should the stern not be clear to go ahead on the engines, a bow breast should be kept under a light strain and, when the ship is headed correctly, the breast should be checked, while slacking the quarter spring. The stern will swing out and clear. All lines can then be cast off and the engines put ahead. To use the bow breast in this manner the bow must be farther out than the stern; otherwise, the ship will come back alongside.

Should the wind prevent the bow from falling off, it will be necessary to go out astern, as previously described for a ship being set onto the pier.

Clearing a Wharf—Current from Astern.

Holding an after bow spring and easing out on a quarter breast will let the stern swing outward. When pointed correctly all lines are cast off and the ship goes out astern.

Working into a Slip.

The best time for entering a slip is when the water is slack. The procedure is the same as in making a pier. In entering, an anchor under the forefoot for snubbing is of great assistance, as it gives greater steering control.

Should there be a good current running, the docking should be done with tugs; but, if they are not available, heading into the current, the ship makes a landing on the front of the pier.

The ship is then warped into the slip. The springs for this purpose should be as short as possible to reduce the radius of the swing, and should be as nearly perpendicular to the keel line as practicable to produce the best springing effect. To protect the ship's side and the pier a camel or suitable fenders are placed at the knuckle of the pier where the pressure is localized. The camel will distribute this pressure over many of the ship's frames, thereby preventing the crushing of them. The ship goes slowly ahead until the knuckle of the pier is amidships. Then the bow spring is held and the rudder is thrown hard over toward the pier, thus aiding in the turn. After enter-

ing the slip, if being set off, the lines should be got out and walked up the pier in short fleets, using them as necessary to hold the ship in. If being set on, lines are run to the opposite side of the slip.

When backing into the slip a camel is not necessary, but the same principles of using the springs apply. The lines, especially the bow breasts, must be very strong, and good seamanship dictates that more than one be run. The additional ones are preventers and are used as alternates in the shifting of the lines for better leads. The vessel is dropped back until the knuckle of the pier is amidships. Then, holding the quarter spring, the bow breast is eased. When the ship is pointed correctly the engine is backed slowly. Deck winches are a help and almost a necessity in the case of a single-screw ship backing in to starboard.

Mooring to a Buoy.

The ship approaches with the current from ahead and the buoy is kept in line with an object on the beach. Picking the buoy up on the lee bow, the ship will be set down onto it. In the case of a single-screw ship, the starboard bow is usually the better, because of the strong tendency for the bow to fall off to starboard when the screw is backed. A man must be placed on the buoy for handling the lines and chain. It is possible to lower him over the bow in a boatswain's chair; however, it is better to send him in a boat to the buoy. First, a hook rope or a strong wire with a shackle is passed to the buoy and secured. Next a messenger is run from underneath, through the ring, and back on deck to the capstan. The messenger is used to reeve the anchor chain through the ring, after which the chain is secured on deck. The buoy ring is now in a bight of the chain. The wire is slacked and becomes a preventer, if so desired. In larger ships the end of the chain is shackled to the buoy ring.

The buoy can be picked up with a fair tide; however, it requires good control of the ship and speedy work on the part of the seaman handling the gear. When the vessel swings it will put a severe strain on the moorings.

Mooring Bow and Stern to Buoys.

The ship should approach slowly into the current on the side from which the ship will be set down onto the buoys. The bow and stern lines should be made ready for running and boats will be required under all but extremely favorable conditions. The ship should note the ranges on the beach abeam for motion over the ground, besides using the lead line for the same purpose. As the engines are stopped the ship will gradually lose headway over the ground. While lines are being run to the forward buoy as in the preceding section, a boat should be used to put out the after lines in a similar manner. After the lines to the forward buoy are secured and the ship has taken up the strain, all slack should be taken in aft and the lines secured. A taut moor should be made to prevent ranging.

Slipping a Mooring.

A strong manila line or flexible wire is run through the ring and back on deck and an easing-out line is secured to the end of the chain. With the slip rope kept taut the chain is eased out and the buoy is now secured by the slip rope only. When slipping, the slip rope is let go in such a manner that the line will be pulled up through the ring.

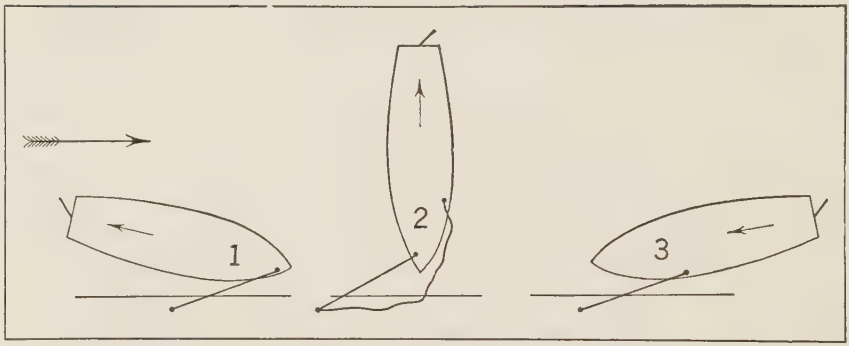
Winding Ship. (Plate **148**.)

Seldom is it necessary to wind ship; but, if it is, a tug, if available, is used. Should none be available, the winding of a small ship may be accomplished by the use of the current. It is safer to let the stern swing outward than it is to let the bow go out, as there is a possibility of damaging the screws when the stern is toward the dock. When the current is feeble and from astern, all lines are slacked except the after bow spring. The stern will go out, but should it not, backing a bit on the inboard propeller of a twin-screw vessel will force the stern out (a form of bank cushion) and into the current. In a single-screw ship, starboard side to, the ship is backed down slowly, but when port side to, it is necessary to go ahead very slowly against the bow spring to throw the stern out. When the stern is out, the cur-

rent will catch it and swing it rapidly around. All after lines are cast off, and by backing a bit the bow is kept clear of the dock. As the vessel swings, a forward bow spring from the other bow is got out as shown in the figure. This is led from well aft on the forecastle in order to increase the effectiveness of the rudder in controlling the swing of the vessel. When the line has a clear lead, a strain is taken on this spring and the other cast off. The ship then goes ahead slowly on the engine. The rudder is used to ease her into the dock.

If the engine is not available, winches may be used, in which case a long line is run from the off quarter, well forward to the

Plate No. 148



dock. This forward quarter spring is an aid in completing the swing should the current be insufficient. Fenders or a camel are placed at the bow, and the ship allowed to take up on the after bow spring. The after inboard lines are slacked and finally cast off.

General Rules for Handling a Vessel.

1. Size up the situation.

2. Keep your eyes open to detect changes in the situation; that is, watch ranges on the shore or on the vessel upon which you are making the approach, to detect being set on or off. When backing, watch your after mast against the shore line for an early detection of the stern falling off to either side.

3. Use minimum speed.

4. Use plenty of power.

5. In a single-screw ship, consider the rudder in relation to

the motion of the screw, and on a twin-screw vessel consider it in relation to the motion of the ship.

6. In a twin-screw vessel, consider the screws going ahead as pumps sucking (bank suction) from between your ship and the dock, if solid, and in going astern as pumps throwing water between the ship and the dock (bank cushion).

7. Remember the stern tends to back into the wind until steerageway astern is reached.

8. When about to touch in making a landing, be sure that there is no fore and aft motion on the ship.

9. Remember your stern—it swings first, when your rudder is put over. Don't try to turn your bow away, and in doing so slam your stern into the dock.

10. Keep your stern clear for swinging either way as long as possible.

11. When in doubt—STOP!

VIII. Rough Weather.

The seaworthiness of a vessel is dependent on three things:

1. Its initial and statical stability.

Initial stability is the stability of a ship when on an even keel. Statical stability is the stability of a ship not on an even keel due to a force having heeled her over.

2. Its range of stability.

Range of stability is the angle through which the righting arm is positive. It is the angle of heel through which a vessel tends to return to an upright position.

3. Its dynamical stability.

Dynamical stability is the work done to heel a vessel through any angle not greater than the range of stability.

Initial stability is measured by the transverse metacentric height in feet, which is the distance from the center of gravity up to the metacenter. The metacenter remains fixed, but the center of gravity may change. Any change in this can be quickly estimated by the formula:

$$GM = \frac{K}{T^2}$$

GM = the transverse metacentric height in feet.

T = time in seconds of a roll from one side to the other.
K (a constant for a particular ship) = .05 B^2.
B = the beam in feet of the particular vessel.

Thus, if the period of the roll is doubled, the *GM* is quartered, and in all probability the ship is in danger. The decision to abandon a ship or to attempt to save her is based greatly on this new calculated *GM*.

This *GM* may be increased by lowering the center of gravity which may be done by completely flooding some of the lowest tanks, and by casting overboard top hamper, boats, torpedoes, spars, and mast. The removal of any free surfaces by the complete flooding or pumping of fresh water or fuel oil tanks and the removal of water in the bilges, will increase the *GM*, especially so if the tanks run athwartship.

A ship with a long easy roll makes a good gun platform and a good passenger ship, but the very fact that she has an easy roll is a sign of a low metacentric height. A ship with a large *GM* will have a quick, jerky roll which is uncomfortable, a poor gun platform, and might be so bad as to snap the masts out of her.

Statical stability for any angle is measured by the righting arm at that angle of inclination. As a ship is inclined, this arm increases until it becomes a maximum when the main deck waterways are awash. Further inclining decreases this arm, until at about twice the angle at which the arm was a maximum it becomes zero and the vessel will no longer right itself.

This last angle gives the range of stability of a ship. It is approximately twice the angle at which the main deck waterways are awash. Therefore, a high freeboard, as compared to the beam, is desirable. Between two different types of ships the relative range of stability is measured by the ratio of freeboard and beam, while between two ships with the same ratio of freeboard to beam, the *GM* is the measure of the relative range of stability.

A stiff ship is not always the safest. The range of stability must be considered. A battleship has three times as great a *GM* (initial stability) as a destroyer and twice the righting arm, but whereas a battleship can roll but 60° (range of stability) before it will capsize, a destroyer can roll 90°. Merchant ships with

their high freeboard compared to their beam are very seaworthy even though they have a low value for their *GM*.

The work utilized in the inclining of a ship is the measure of its dynamic stability. If the force of the sea acting on a ship becomes great enough to heel her over until the righting arm becomes zero, the ship will not be able to right itself. The force of the sea is greatest when the period of the ship and that of the waves are in synchronism, thereby building up a much deeper roll. This can be controlled by the ship changing course or speed or both, which alters the apparent period of the waves relative to the ship. A ship lying to will lie in the trough or with the wind and sea on the quarter, depending entirely on the type of the ship and the nature of her loading. To keep a ship in a desirable position is difficult at times. It is easier to hold the sea on the port bow of a single-screw ship than on the starboard, as the screw tends to force the bow to port.

Headed into heavy seas, the ship must proceed at a minimum speed and even then green seas may sweep the forecastle. As these seas have a great force and destructive power, the fore hatches must be well battened down and all ports firmly secured. Should they become damaged, a small ship can lie to under a sea anchor or a large manila line from the bow or stern, as she drifts to leeward.

Running slowly before a sea has an advantage for certain vessels; however, it must be done at slow speed and even then there will be a tendency for the seas to poop the ship, sweeping her from aft. The yawing will be great.

Use of Oil. (Plate **149**.)

Oil is seldom needed to calm the seas; yet, when it is required, it is invaluable. The fact that all United States Registered machinery propelled ships of over two hundred tons must carry from 30 to 100 gallons (the amount dependent on tonnage) of oil for this purpose, shows that it should be considered of use.

The particles of water in a wave move mostly in a vertical direction. As the wind increases, it sweeps the crests from the waves, building up one large wave at the expense of many others. The water is thus set in motion and the waves become destructive

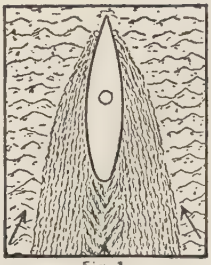


Fig. 1
Running before a Sea.

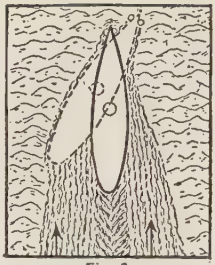


Fig. 2
Running before a Sea and yawing with danger of Broaching-to Distributing oil from bow alone (2) leaves quarter unprotected as ship yaws. Use method of 3.

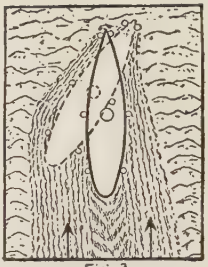


Fig. 3

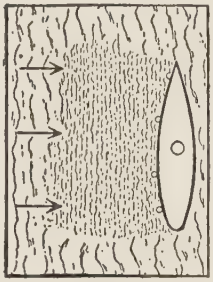


Fig. 4
Lying-to with sea on the beam.

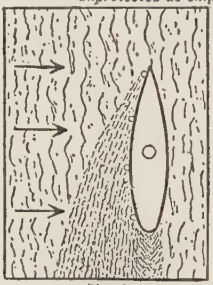


Fig. 5
Running with sea on the beam.

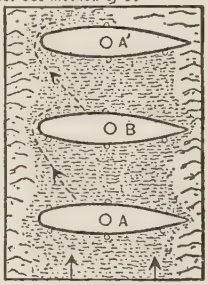


Fig. 6
Communicating by Boat.

Note:-Fig.6 { *"A" Stops to windward to lower boat and goes to leeward to pick up boat.*

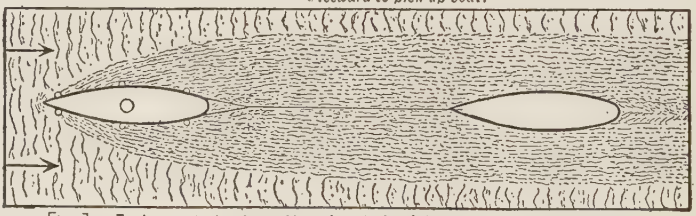
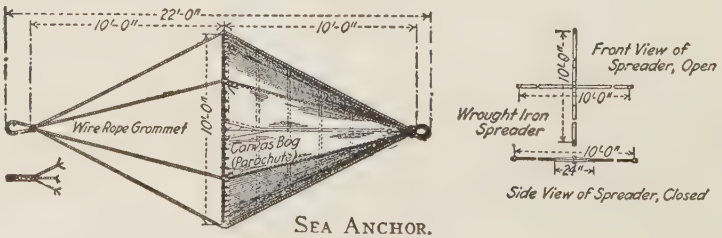


Fig. 7 *Towing against a Sea. if sea is not ahead, both ships use oil as in Fig. 5.*

Fig. 8 *At Anchor Haul out bag to block on cable.*



SEA ANCHOR.

THE USE OF OIL.

in force. If the adherence between the air and the water is reduced, the waves will remain in their simple form. It is found that certain substances, mostly oils, will do this, as they have lower adherence factors with air, than water has with air. Soap is one of the best agents for reducing this adherence; yet, it is not practical as it mixes with sea water, thereby requiring too great a quantity. A second requirement, therefore, is that the substance must float on the water and not mix with it. Oils fulfill this. A third requirement is that the substance must spread rapidly, which means that the oil must have a low viscosity. In general, the best substances are vegetable and animal oils. Mineral oils of low viscosity are only fair as they do not spread as rapidly as the other oils.

Two gallons an hour should be more than a sufficient quantity. Too much is a menace when working around a derelict where there is a fire or where people are in the water.

Oil must be to windward to be of use. As a ship drifts rapidly to leeward, while the oil drifts slowly, the oil will appear to work to windward. Therefore, when lying to, the oil should be put over the windward side. To keep the heads flushing with the oil dripping slowly into them is a convenient and effective means of oil distribution. If a sea anchor or drag is in use, a canvas bag of close-woven canvas, stuffed with oakum, cotton, kapok, or waste, saturated with oil, and punctured in a number of places by a large sail needle, can be secured to the sea anchor and thus make a good slick to windward. When a ship is anchored in an open roadstead an oil bag on an endless line can be run out to a position on the anchor chain.

A ship crossing a bar should wait for a fair current so that oil placed on the water will be carried over ahead. The vessel should then proceed to cross the bar.

§ II.

IX. Destroyers.

General. There are at present, as has been described in Chapter III, three types of destroyers in commission in the United States Navy; the 1200-ton destroyer built in large numbers during and immediately following the World War, the 1500-ton destroyers and the 1850-ton destroyer leaders. All are

vessels having a high forecastle and a low stern, light scantling, small beam as compared to their length and comparatively large power.

The high forecastle of these vessels plays an important part in their maneuvering qualities; acting as a permanent jib, which, while helpful under some conditions is a serious handicap under others. It must always be kept in mind and allowed for, its principal effect, being of course, to make it difficult to bring the vessel up into the wind.

Due to their light scantling destroyers should not be brought alongside each other or alongside a pier so that they bring up with a heavy blow.

The high power of destroyers is of course a distinct advantage when working in close quarters. Destroyers unlike many turbine driven ships have ample backing power for almost any situation. Their narrow beam as compared to their length gives the screws a relatively smaller turning moment than is the case in larger vessels and vessels of greater beam as compared with length.

Maneuvering. It is clear that no hard and fast rules can be laid down for the handling of destroyers any more than for any other type of ships. It rarely happens that conditions are identical on any two occasions, even for the same vessel performing the same maneuver in the same place. A destroyer will make more leeway when her oil tanks are light than when she is fully fueled. If down by the stern the bow will fall off rapidly in making a pier at low speed, while if down by the bow she may decide to lie broadside to the wind and drift bodily to leeward.

When turning a destroyer with one engine going ahead one-third and the other engine backing one-third the ship will gather slight sternway. As a general rule the ship will handle much better if making headway and therefore it is best to have the ahead engine making one-third speed more than the backing engine. If it is desired to turn the vessel on her heel it will be necessary to change the speed of the ahead engine from time to time to prevent the backing engine from taking charge.

It must be remembered that a destroyer has a relatively large amount of deadwood and that as a result she has a large turning circle.

The effect of the screws in maneuvering a destroyer is fully discussed in the first part of this chapter. The general prin-

ciples are entirely applicable—the small turning moment due to narrow beam is, however, peculiar to the type.

The propellers extend well beyond the hull and care must be exercised not to damage them in going alongside.

In narrow waters, under adverse conditions of wind and tide two destroyers may be secured together and advantage taken of the increased turning moment gained by using only the outboard propeller of each ship. In this case it is, of course, necessary to have all slack out of the mooring lines so that they will not be parted when the direction of motion of either or both propellers is reversed.

When getting underway or coming to anchor it is customary to set the standard speed at 15 knots. This is desirable as the captain becomes thoroughly familiar with the power to be expected when any particular speed is ordered. Experience has shown that 15 knots gives ample power both ahead and astern for working in close quarters.

Destroyers are light craft with very powerful engines and there is an easily understandable fascination in handling them which frequently leads to the taking of unnecessary chances. A good destroyer officer is one who uses the powers at his command daringly when necessary, but who does not invite disaster by rashness. It happens from time to time that an engine will not follow the signal, through fault of either personnel or material; and if this happens when the commanding officer is charging into a landing at high speed, trusting to his backing power to stop in time, the result may be a smashed bow or some worse accident, resulting not from an effort to perform some important service, but merely from bravado. Engine room telegraphs may jam or carry away while on full speed ahead or astern.

Going Alongside a Pier. The destroyer officer gets constant practice in making piers under various conditions of wind and tide. The discussion in this chapter on "Handling Twin Screw Steamers" applies to destroyers as well as any other vessel but the peculiarities of the type must be kept in mind.

In making piers it is well to have your best steersman at the wheel. If he is an experienced man it is only necessary to explain to him what it is desired to do and he will usually place the ship as directed with but few if any orders. The position

of the conning officer is a matter of personal preference but it is usually found that the wing of the bridge on the side toward the dock is an advantageous position. From here, the wheel, the engine telegraphs, and the pier are all in view. Also from this position it is easy to determine whether or not the stern is swinging.

The light fittings, large power and small lines make it especially important to exercise care in warping or springing around piers. It is often necessary to work the engines in opposite directions with great power, but great strain must not be brought on the lines by imparting motion to the vessel.

The speed to be used in approaching a pier should be in keeping with the space available ahead or astern of the landing to be made and with weather and harbor conditions. It often happens that the landing must be made when other vessels are so moored as to present but little of the pier in excess of that absolutely required for the destroyer, in which case caution is obviously essential.

The pier should be approached at a slight angle (10°–20°) and the engines stopped with sufficient headway to overrun the landing slightly. When it is certain that the ship's momentum is sufficient to carry the bow into heaving line distance the engines are stopped. Heaving lines are passed as soon as possible and the mooring lines hauled ashore. The engines are worked to bring the ship in to securing position, care being taken that springs and breast are properly led and that neither bow nor stern is brought in too sharply as any localized pressure may result in damage to the frail shell plating.

When the wind is blowing onto the pier it is best to approach parallel but well clear—just within heaving line distance. As the destroyer loses headway she will drift easily and bodily into the pier. Should the wind catch the bow and start it swinging rapidly the inboard engine should be started ahead and the outboard engine backed to keep her parallel. If this is not done immediately the bow begins to move, it will be found practically impossible to check the swing.

When the wind is blowing off the pier it is often necessary to use greater speed and to approach boldly, owing to the rapidity with which the destroyer drifts to leeward as she loses her headway. In this situation it is safe and best to begin the ap-

proach as if to make a parallel and close aboard landing. As the pier is neared the effect of the drift will be felt and the rudder must be used to point the bow very close in, and this will result in a cant towards the pier. As soon as it is assured that a position will be reached from which the bow lines can be cast, the rudder should be thrown away from the pier and the outboard screw backed in order that stern lines may be got out. It is now important to remember that the destroyer pivots just abaft the bridge, that there is a capstan forward but no winch aft, and that the heavy stern can be brought to a securing position only by use of engines and springs. The wind being off the pier, bow lines should be run as quickly as possible but should immediately be slacked to avoid a strain forward and to permit the bow to fall off as may be necessary in order that the stern may be brought in smartly by engines and rudder. Bow lines once being passed, the bow can always be warped in by means of the capstan after the stern is in the desired position.

Various conditions of tide are encountered, and an officer having to work habitually around a certain locality will in time become accustomed to the peculiarities of the currents; but much time and trouble may be saved by making a study of those peculiarities from the first, through systematic observations of the strength and direction of the current from hour to hour through several days, keeping a careful record and referring all hours to the time of high and low water as given in the tide tables. It must be kept in mind that currents are often baffling around the face of a pier and that the surface current may be running quite differently from the main current of the stream.

When the current is running strong and parallel or nearly parallel to the pier, the wind may be considered as of secondary importance, for the destroyer is long and narrow, and when placed at an angle from the axis of the current will rapidly be carried towards or away from the pier depending upon that angle.

If the current is forcing the vessel on to the pier, as will often happen where piers are athwart the stream, it is important that engines be maneuvered to keep squared up with the pier as the vessel drifts in with the current, and to see that sufficient fenders are ready in place, otherwise serious local damage may be caused to the shell plating.

If the current is running away from the pier, speed must be

used, lines must be got out smartly, and backing power and good judgment depended upon. Once the lines are out, the stern must be brought in by springing upon the waist line and by skillful use of engines and rudder.

To make a landing with a fair tide is very difficult, as the slightest cant towards the pier will bring the current under the inboard quarter. This force will probably overcome all effort of engines and lines to bring the stern in, especially if strain be brought on a forward line, which is an error commonly made (every destroyer officer learns that it is useless to attempt to spring in on a bow spring). The ship should be brought as nearly parallel to the pier as possible, preferably with a slight cant outward, and the after lines got out smartly and held. If a line can be secured aft it will act as a spring, and the current will bring the ship in readily. The bow will take care of itself. It will ordinarily save time, with this condition of current, to turn and stem the current or to drop an anchor and swing before approaching the pier.

Going Alongside a Vessel at Anchor. This is very similar to going alongside a pier except that conditions of wind and current to be met are usually more favorable. The destroyer must keep clear of an overhanging stern or of any projections from the side of the vessel approached and if possible select a part of the ship's side where there are no projections. A whale boat or a triced up gangway may inflict serious damage to the destroyer's upper works. The greatest danger to be avoided is that due to the possible yawing of the vessel at anchor and this is especially to be guarded against if the vessel being approached is a destroyer, for these craft yaw very freely when anchored and riding to wind or current. Just as the lines are about to be passed, after an approach that has looked perfect, the stern of the anchored vessel may swing so unexpectedly as to make it impossible to avoid a sideswiping blow. A destroyer riding to a long scope of chain yaws excessively from the effect of the wind on her high forecastle and her bow may fall off when she reaches the end of her arc. If this happens, the vessel going alongside may find her stem unexpectedly brought up against the side of the other destroyer, or she may "sweep the rail" of the vessel anchored. Whenever a destroyer is going alongside of another it is well for both to place their inboard anchors on deck so as to

avoid, as far as possible, damage should one "sweep the rail" of the other.

There is rarely any difficulty in going alongside a vessel at anchor and the fact that she is at anchor makes it reasonable to suppose that there will be ample maneuvering room, except when she rides with her stern close to the beach; hence caution, not high speed, is all that is required. The approach should be made fairly well clear with a slight cant inward, and the stern should be brought in and the bow carried out by backing the outboard screw and by use of rudder as forward lines are passed. Here a spring leading forward from the after forecastle chock of the destroyer can be held and the ship breasted in easily by the current, care being exercised not to get the current on the inboard bow. Unlike the situation in going alongside a pier, the forward lines are the more important, for the stern will be taken care of by the wind or current to which the anchored vessel is riding and engines and rudder can easily be used to assist in paralleling the two vessels as they draw together.

Should the vessel ride at anchor so that her stern tails close to the beach, it is sometimes feasible to make the landing stern first, but if the wind is blowing very strongly this should not be attempted. It is here that an anchor may be used to advantage. *A* approaches with the wind and drops an anchor off the bow of *B*.

The anchor is held under foot—and chain veered if dragging is noted—until the destroyer swings to the wind. Forward lines are now passed, dropping down by veering chain if necessary, and when these lines are secured on *B's* deck *A* may weigh her anchor and warp alongside by means of a forward line, assisted by engines and rudder.

Getting Clear of a Pier or Vessel. When the engines have been reported ready and all lines singled the vessel is ready to proceed. A destroyer should be backed away from a pier or other vessel unless the conditions are such that it is absolutely necessary to go out ahead.

Leaving the pier or another vessel is quite simple unless the destroyer is being set on by a strong wind or current. If the wind and current are from ahead the destroyer may be taken away from the pier by casting off all lines and backing one-third on all engines with rudder amidships. The wash thrown between the

pier and the ship by the inboard propeller will breast the ship out from the pier. Should there be a tendency for the bow to cant in or out it can be corrected with a few degrees of rudder. The bank cushion is of course far more effective if the pier is solid.

If the wind or current is setting the destroyer on the pier it is well to work her stern out ten or fifteen degrees before backing clear. This can readily be done by holding an after bow spring and going ahead slowly on the outboard engine. If the wind is strong the inboard engine should be backed slowly when the propeller is clear of the pier. This will assist in working the stern out and in addition when ready to go astern no time is lost in opening the throttle. When the stern is canted out sufficiently let go the bow spring and immediately back one-third on all engines. Should the set on the pier be very strong the destroyer should back away at two-thirds speed. In this case as in the first the rudder should be used if there is a tendency for the stem to sweep the pier as the destroyer backs clear. A few degrees of rudder toward the pier will usually correct this difficulty. If the rudder is not sufficient the inboard engine may be slowed.

Unless it is necessary to go out ahead no difficulty should be experienced when leaving the side of an anchored vessel. When all is ready for getting underway all lines are cast off and the destroyer backs one-third on all engines with rudder amidships. Again the wash thrown forward will breast the two ships apart and the destroyer backs clear. Should there be a tendency for the bow to cant one way or the other as sternway is gathered it may be corrected by a few degrees of rudder.

If it is necessary to get out from the middle of a nest, mooring lines are passed around the bow of the destroyer about to leave so that those on either side may be again nested without getting underway. When this has been done the destroyer which is to clear backs out in exactly the same manner as described in the previous paragraph.

When it is necessary to go out ahead, as when the destroyers are tailing into the beach and there is insufficient water under their sterns to back away, caution must be exercised. Should there be a strong wind or current from ahead the situation is somewhat simplified. In this case the bow will fall off as the

forward lines are slackened. Then with the stern close in to the stern of the anchored destroyer the outboard engine may be put ahead. As way is gathered the rudder should be placed towards the other vessel and the inboard engine started ahead. With rudder towards the anchored ship the destroyers stern will be kept clear and due to the destroyer's large turning circle she will round the bow of the anchored vessel without danger.

More frequently than not, when it is necessary to go out ahead the conditions of head wind and current are not to be met. If the wind is setting the ship against the anchored destroyer unusual caution is called for. In this case the chain of the anchored destroyer will probably tend across the bow making the getaway more difficult. If in getting away the stern is not thrown well clear there is the danger of fouling the anchor chain with the inboard propeller. In this case a satisfactory method is to ease off the bow lines and give the outboard engine a slight kick astern to bring the sterns together. The bow lines must be tended in order to check them should it appear that the propeller guards will foul.

Let go all lines and go ahead two-thirds on the outboard engine with rudder amidships. If the stern does not pull clear of the anchored destroyer back the inboard engine one-third and go ahead standard on the outboard engine. This should pull the stern out. When the bridge is about abreast of the anchored destroyer's chain, the rudder should be thrown full towards her and the inboard engine stopped. This will cause the stern to sweep out and clear the chain while the destroyer makes a turn around the bow of the anchored destroyer.

Handling Destroyers and Other Small Craft in Communicating With Larger Vessels Underway With Way On.

Speaking Large Vessels. The greatest care should be taken in approaching large vessels which are underway. It is especially dangerous to attempt to take position full on the beam. The safe course is to come up on the quarter of the large ship and carry on communication with the after part of the ship. This leaves the smaller vessel free to swing her stern towards the larger one if necessary for increasing distance, which could not

be done if she were entirely overlapping the larger vessel and chanced to get a little too close. When a small vessel is running parallel to a larger one and rather close aboard, the smaller craft is dwarfed and her commanding officer loses power to realize the exact situation. He cannot correctly judge the steadiness of course of the big ship, changes in her speed, etc., and should she slow for any reason, he may be under her bow before he knows it. In repeated instances it has been proved that in such a position he is apt to close in without realizing it until he is so close that, if he puts his rudder over, his stern will take against the ship's side and a smash will follow. This is but one example of the wisdom of the old destroyer rule: "Keep your stern clear to swing, no matter what happens."

X. Submarines.

In treating of the handling of this special type of ship, matters relating to the details of effecting submergence as well as to the structural characteristics and mechanical appliances for so doing have been omitted. The modern submarine is a complicated combination of mechanisms, the study and comprehension of which requires specialist training and considerable experience in the craft. In a like manner, comment on the operating of this type has been limited to that which bears on the characteristics and peculiarities of the submarine as a ship.

The modern submarine is a ship, which, due to structural characteristics and appliances peculiar to the type, is capable of being submerged and of being controlled at various sub-surface depths. Aside from attempts to insure greater safety of operation, modern design has tended toward the normal hull form, greater reliability in motive power, increased offensive qualities and greater habitability, to the end that this type may possess increased sea-keeping ability and, in consequence, fulfill its mission as an offensive and scouting arm of the Fleet.

Until such time as means of propulsion is perfected which will permit the submarine to operate both surface and submerged by using a single type of motive power, it will be necessary to divide allowed machinery weights into two means of propulsion, one for use on the surface and the other, submerged. For sur-

face propulsion the submarine relies on various types of heavy oil, internal combustion engines operating on the Diesel cycle. Through mechanical and electrical arrangements, power is shifted from the internal combustion engines, upon submerging, and the submarine is propelled by electric motors which receive their power from the storage battery installation. Thus it may be seen that, whereas in the design of a surface ship of a given tonnage a certain percentage of weight may be allowed for propulsion, the weight for the power plant of a submarine of the same tonnage must be so divided as to provide two means of propulsion, one for surface use and the other, submerged. This requirement results in reducing greatly the power available for maneuvering and makes this type relatively sluggish in operating, as compared to surface ships.

Handling on the Surface.

The essential rules for handling submarines on the surface are, in general, those applicable to surface ships. There is one important point of difference to be found in the fact that, whereas the stern of a surface ship must be watched with care in handling alongside, so as not to damage the propellers, both the bow and stern of a submarine must be considered as being "tender." This is due to the fact that forward are installed submerged torpedo tubes with their muzzle doors and shutters, as well as the bow plane operating gear. These appurtenances are contiguous to or abut slightly from the hull. An error in judgment in handling a surface ship alongside may result in damaging the hull structure of the bow or at least in lowering one's pride as a ship handler. In a submarine, a similar error may result in underwater damage which may render the ship inoperable until repairs have been effected. The stern of a submarine is more tender than that of a surface ship due to the fact that, in addition to protruding propellers, the submarine is fitted with stern planes and their supporting skegs, which, in most cases extend beyond the line of the hull at that point. As these appurtenances are submerged, damage to them will in most cases, require that repairs be done in dry dock.

In general, submarines handle well on the surface and conform to the maneuvering characteristics of surface ships. Ample

propulsive and steering power are available for use. Due to the location of the conning tower and bridge structure, at or near the pivoting point, officers handling submarines possess an advantage over those handling surface craft, in which latter, the bridge is generally placed well forward of this point.

Some classes of submarines are equipped with engines which may be reversed, while in others, not so equipped, the electric motors are used for maneuvering. In the former case, the engines should be used exclusively for maneuvering on the surface as they are more powerful than the motors and, as a result can develop greater backing power when needed. In addition to this advantage, the propellers can be reversed quicker in an emergency than in the case wherein power must be shifted to the electric motors to effect backing.

Due to the structural peculiarities mentioned above, it is standard practice to back down in clearing the side of a tender or in getting clear of a nest.

Heavy Weather.

Submarines, properly handled, will live through any storm. The only requirements are that the hatches be secured in plenty of time to prevent water entering the boat and that there is plenty of sea room. A submarine can be handled from within almost as well as from the bridge, except of course in narrow waters; so on the approach of a storm one should not run the risk of losing a man by trying to keep the bridge control too long. Do not pound into a heavy sea. To do so will strain the hull and will surely bend or break the torpedo shutters. It must be remembered that the torpedo is the principal offensive weapon. A submarine, like any other propeller-driven ship, will naturally ride most easily with her quarter to wind and sea. If forced to lie-to, do so in this position. On the new types of submarines fitted with a covered pilot house, it is possible to keep men on the bridge when lying to.

If it is of advantage to run before the sea, it can be done more easily by regulating the speed to the length of the waves. This will have to be done by running on the motors, as the engines, in some boats, will not operate slowly enough. If the speed is too great, waves will come over. Oil may be used to

advantage as with surface vessels; a good way to apply it is to pump it out with the engine room bilge pumps. If the bilges are dry it will do no harm to pump a little water in, and then, after adding a little oil, to pump them dry again.

No difficulty should be experienced in submerging in a seaway if the sea is brought abeam or abaft the beam.

Handling Submerged.

Whether or not the boat handles well submerged depends on the design and the trim. The latter is all one can control so it behooves one to get the best results by careful trimming. The practical definition of the term "trim" of a submerged vessel includes two separate and distinct factors, viz.:

(*a*) The condition of buoyancy.

(*b*) The angle between the longitudinal, or fore and aft axis, of the vessel, and a horizontal plane, passing through the center of buoyancy.

When the movable ballast of a submerged vessel is so arranged that the buoyancy of the vessel is neutral, that is neither positive nor negative, and the angle between the longitudinal axis and the horizontal plane is zero, the vessel is considered to be in neutral "trim." Heavy seas will make a difference in handling, particularly near the surface, but the one big factor over which the Commanding Officer has control is the trim. A poor trim can be handled by the use of high speed, but this is unseamanlike and only in grave emergencies should the trim be neglected.

The effect of speed in handling submerged is tabulated below:

High Speed.

1. Requires small plane angle.
2. Requires small angle on boat to change depth.
3. Boat can be badly out of buoyancy trim.
4. Boat can be out of trim fore and aft.
5. Planes are difficult to operate.
6. Boat changes depth and angle very quickly.

Low Speed.

1. Requires large plane angle.
2. Requires large angle on boat to change depth.
3. Must be trimmed accurately as to buoyancy.
4. Must be trimmed accurately fore and aft.
5. Planes easy to operate.
6. Boat changes depth and angle slowly.

On the surface a submarine will carry its way as far as any other vessel of the same tonnage; but submerged the way is lost very quickly. This should be remembered, as it may be of value when it is necessary to decide whether to surface or go deep to avoid traffic. Another point to remember is that backing the screws while submerged will tend to drag the stern down. This may be of value when the boat is heavy forward and going down rapidly.

When submerged the turning circle is increased. The same principles apply when backing the inboard screw submerged as when on the surface. When turning with hard over rudder a heel is given the boat, the degree depending on the speed. This list throws the rudder out of the vertical plane, thus giving it some of the characteristics of the diving planes. This makes depth keeping during a turn difficult and should be kept in mind when about to fire torpedoes, at which time accuracy of depth keeping is essential. When steering a straight course a maximum of five degrees rudder angle should suffice.

When running at high speed submerged the bow planes are usually set at an angle, determined by the trim, which will allow a minimum use of the stern planes by which the changes of depth are controlled. At low speeds the reverse is true. The stern planes are set and the bow planes used, raising and lowering the boat by their planing effect without changing the angle of the boat. If the stern planes are used for depth keeping at slow speed it must be remembered to use them in the opposite direction to that used in changing inclination. To put the boat down by the bow the stern planes are put down, actually raising the stern and forcing the bow down. If the planing effect is wanted, a smaller angle of plane is used; and on account of the low speed, the water acting on the lower surface of the planes will tend to raise the boat rather than change its inclination.

When firing torpedoes on the smaller boats it is usually necessary to give a large angle of dive rudder on the bow planes in order to overcome the momentary tendency of the bow to rise during the interval that the torpedo tube is still filled with air after the torpedo has been expelled, as this, in effect, removes temporarily a large weight from the bow.

Periscopes. A periscope is an instrument for conveying to the eye of the observer, inside the submerged submarine, an image of objects on and above the surface of the water as the observer would see them if his eye were at the height occupied by the upper or object end of the instrument. It consists of a long tube projecting upward through the hull of the submarine so that the upper end will be three or four feet above the water when the boat is submerged to a depth sufficient for concealment. Behind a window in the upper end is a prism, so placed that the rays of light striking it are reflected downward through the tube where they pass through the object glass, of what is, in effect, a telescope. The rays from the object lens are again bent by a prism so that they pass into the submarine in a horizontal pencil. The periscope may be housed in a well when not being used.

Some periscopes are fitted for scanning the sky by tilting the upper prism. These are called "altiscopes." In modern periscopes the "altiscope" or "sky searching" features are combined with the ordinary periscope features, the combined instrument being known as an "altiperiscope." Nearly all periscopes are bifocal; that is, have two powers of magnification. The lower or "normal" power is 1.5 power while the higher magnification is usually 6 power. The slight increase over unity in the lower power is necessary to compensate for the loss of light and the "tube effect" in the instrument.

The lower power with a large field is used when an object is close aboard or when making a search. As the field of the high power is only about one-quarter that of the low power, it is easier to pick up an object with the latter. After finding it, a careful examination may be made using the high power. When nearing another vessel when submerged the low power should be used, as high power may give an incorrect idea of distance. Telemeter scales are placed in the fields of all periscopes as an aid in estimating ranges. These are very valuable and a con-

siderable degree of accuracy may be attained by their use. Periscopes are provided with azimuth circles for taking bearings and setting sight angles for torpedo fire. It is important that the periscope be accurately boresighted; that is, the periscope must read zero on the azimuth circle when the vertical wire splits the center line of the boat or torpedo tube nest.

In conclusion, stress must be placed on the fact that one man, the officer conning, controls the maneuvering of a submerged submarine. This is due to the fact that but one periscope is displayed at a time, and then only for a sufficient interval to make necessary observations. As the safety of the ship and crew depend upon efficient observations through the periscope, it is needless to say that the officer conning a submerged submarine is charged with graver responsibilities than is his fellow-officer on a surface ship, who has numerous assistants to aid him, when desired

CHAPTER XV.

STATION KEEPING AND MANEUVERING IN FORMATION.

The following is a general discussion of the difficulties connected with maneuvering ships in tactical formations from the point of view of seamanship, rather than that of tactics. We may regard tactics as definitely prescribing certain things that must be accomplished; while seamanship deals with the manner of accomplishing them. The two subjects necessarily overlap throughout a considerable field, and within this field it is impracticable to discuss one without the other. For this reason it is necessary to comment upon some phases of tactics in this discussion.

The exercising of ships in formation is designed as a preparation for battle. However, it may be questioned whether such preparation will completely overcome the difficulties which, in time of battle, will be added to those normally connected with station-keeping and maneuvering. The smoke from guns and funnels of ships will tend to obscure the view from the conning station in all directions, especially ahead. The ship next ahead will be seen only part of the time; the leader of the column probably not at all. The use of instruments for keeping position will be impracticable most of the time.

In ordinary cruising and maneuvering the conditions are much better; the next ahead can be seen at all times, the leader occasionally; and stadimeters and range finders are always available for measuring distances. It is questionable, however, to what extent advantage of these conditions should be taken in training for battle. Certainly a constant effort should be made to train the eye in judging distances, both by day and night—the latter with and without the aid of running lights. It would seem desirable to recognize the fact that in only very exceptional circumstances, such as will rarely exist in battle, can vessels in column accurately keep their proper distances from the leader.

Whatever method is used for determining distance, it will usually be found easier to maintain a reasonably accurate position than to regain it after it has been lost. The moment a vessel begins to close up or drop back, the speed should be changed enough, and only enough, to check this relative movement. This is better than to wait until the error is so great as to call for a more radical change, which, if prolonged even a very little more than necessary, throws the position out in the other direction.

It seems probable that in battle, each ship will usually be reduced to the necessity of keeping distance from the next ahead, and that there will frequently be a good deal of uncertainty even about this distance. There will be times, however, when it will be practicable to judge whether or not the next ahead is approximately in position with reference to her own next ahead. Thus by observing as many ships ahead as can be seen, whether one or more, it will often be possible to discriminate between a real and an apparent error in position, and to avoid the vexation of closing up on the next ahead only to find her a moment later dropping back, because she, herself, has been ahead of position.

In spite of all that can be done, a ship will at times get badly out of position. It may be that her revolutions are not quite true to standard or that she has been badly steered, or that the vessels ahead have been erratic in their station-keeping. When distance has been lost from this last cause, caution must be exercised in regaining position, as the other ships may at any time resume standard speed.

Probably most of the trouble in station-keeping comes from this irregularity in the speed and steering of the various ships. Every effort must be made to keep speed and steering as uniform as practicable. Good steering can be insured by the careful training of steersmen and by emphasizing its importance at all times. Of great assistance to the officer of the deck, in his efforts to maintain a uniform speed, are the electric revolution-telegraphs which are now installed in the larger ships. The order for the number of revolutions to be made is transmitted electrically to the engines, and upon carrying out this order the engine room transmits back to the bridge the actual number of revolutions being made, which is a constant check for the officer of the deck.

While perfectly uniform speed is more important on the part of the guide than on that of the other vessels in the formation, it, nevertheless, requires constant attention on the part of all. The importance of acquiring the ability to keep position with a minimum number of speed variations is realized when the amount of fuel oil consumed under such circumstances is compared with the amount used when the vessel is so handled that she incessantly ranges up and drops back. The fuel oil saved by effecting a minimum number of speed changes increases the cruising radius of the vessel concerned and enhances her value as a fighting craft. Of course, the closest cooperation between the bridge and the engine room is necessary so that the officer of the deck will know at all times the exact number of revolutions the propellers are making.

An excellent means of developing skill in using a minimum number of speed changes in formation is by steaming in line of bearing. Here, errors in speed manifest themselves immediately, and, normally, inconvenience no one but the offender. For good results here, as in other formations, the steadiness of the guide is of utmost importance.

Under conditions as they actually are, some variations in speed must be anticipated. When such changes of speed are made it is very important that other ships of the formation be notified coincidently with the changes by the smart handling of speed cones, speed flags or other indicators. The officer of the deck must be constantly mindful of the speed indicators his vessel is showing so that the other ships in the formation, especially those astern, can govern their speed accordingly.

Attention has been called to the importance of judging distance without the use of station keeping instruments. The clearness with which details of construction on the ships ahead can be seen is of great importance. At a certain distance, for example, objects on the ship ahead will line up, and with a change in this distance they will become out of line. This affords a means of determining whether the distance is too great or too small, providing the observer always stands at a fixed point. Pitching of the observer's vessel will make estimating difficult, but with practice the mean can be recognized. Even at night with ships darkened, if the weather is reasonably clear, this method is helpful; the booms, funnels and masts of a ship as

much as 1000 yards distant being visible through good binoculars. If, before the visibility is lessened because of darkness, the ship next ahead is observed through binoculars when the distance is correct, a certain portion of the field of the binoculars will be occupied. When darkness sets in the silhouette of the ship ahead can be picked up through the binoculars and the amount it covers the field can be compared with the amount when the distance was correct. Of course, the larger the ship ahead appears the shorter the distance. Knowledge of the exact distance to the next ship ahead is not as important as knowing whether or not the distance is being increased, decreased or maintained.

In addition to being able to see the outline of ships ahead in the dark, very frequently the wake will show up with more or less phosphorescence.

It is important to recognize that the speed of the ship is reduced by the use of the rudder. A poor steersman will make it difficult to keep position. When steering with excessive rudder the ship not only ranges over a greater distance than necessary, but the drag of the rudder holds her back and reduces her speed materially. It should be emphasized to all steersmen that a steady course must be maintained, and that this shall be done with the least possible amount of rudder.

It is a common error for inexperienced officers to make frequent and radical changes of speed in keeping station, because of their failure to allow for the interval which necessarily elapses between the signal for increasing or decreasing the number of revolutions and the time the change actually affects the ship's speed through the water. It is commonly known that a large ship holds her way for a long time after the engines are stopped, and that she does not gather way, if at rest, until an appreciable time after the engines are started, but it is not always realized that a corresponding delay must be anticipated in the response to a change of a few revolutions when the ship is already making way. Thus the beginner, impatient to regain position, and seeing no effect from his adding or subtracting one or two revolutions, is tempted to call for two or three more; and when, finally, the ship begins to forge ahead or drop back, his inclination is to let this continue until he is nearly or quite in position, forgetting that the effect of the change in revolutions of his propellers will continue to affect the speed of his ship for an appreciable period

after the engines have resumed their standard speed. This leads, of course, to almost endless changes in the revolutions, and keeps the ship perpetually ranging ahead of position and dropping back astern of it.

Such variation in speeds and unsteadiness in station keeping can be avoided to a great extent by the beginner by regulating speeds in accordance with a simple calculation. Let it be assumed that a ship has dropped astern of her position a hundred yards and must regain her place. Having steadied her in this position, it remains to close in on the next ahead to the proper distance, and avoid overrunning. Suppose that five revolutions per minute correspond to one knot. This means that five revolutions per minute will give 2000 yards in an hour. One revolution will thus give 400 yards an hour, or 100 yards in fifteen minutes. If, therefore, we add one to the revolutions which hold her steady, we may expect to regain position in fifteen minutes. To reduce the time to five minutes we must add not one, but three revolutions. We will not be actually in position at the end of the five minutes, for it will take a perceptible time to pick up the extra speed; but the interval for continuing the three extra revolutions will be five minutes, since it will take approximately the same time to run off the extra momentum that was required to pick it up, and the ship should, theoretically, settle into the proper position with a speed which will just keep her there.

Similar conditions govern the reverse operation of dropping back when a ship is ahead of position.

In all changes of speed, and indeed at all times when in formation, it is good seamanship to give all possible consideration to the next astern. If the next ahead starts dropping back suddenly upon you, and the next astern is rather closer than he should be, there is no harm in sheering slightly out of column until the vessels concerned have time to adjust themselves. And in the simpler case where you are merely called upon to open out for regaining your position, it is well to do this slowly, giving notice of your decrease in revolutions with the speed indicators.

It is an accepted rule of tactics that in column a ship is better ahead of position than astern of it. In compound formations (guides rather than individual ships on line of bearing) it is of great importance that individual columns shall not be lengthened out unduly, because the rear ship of a column which is taking

up more than its share of sea room will crowd the head of the next column when the fleet passes into simple formation. In compound formations, we may place a great deal of emphasis upon this established rule. As there are only a few ships in the individual column, the dangers of congestion because of keeping closed up are not serious.

In spite of all precautions, interference will occasionally arise between the rear of one subdivision of the fleet and the head of the next one, in passing from one formation to another, and it is well to prescribe rules as to who shall give way in such a situation, and the manner of doing so. It is well to require the rear vessel of a leading unit, when she finds herself so far astern of position as to embarrass the leader of the next unit, to give way in order to ease the situation, by sheering slightly out of column temporarily, thereby permitting the leader of the other unit to swing into her proper place. By this means the giving way vessel alone will be out of position, while permitting a tactical unit of two or more ships to come into its proper station. In connection with compound formations it is well to remember that when a tactical unit joins a column with units ahead and astern that, in swinging in, the last ship of the unit must allow for her considerable reduction of speed because of the drag of the rudder, and not embarrass the leader of the next unit astern.

Keeping Position in Line.
(Line of bearing normal to the course.)

One of the most important requirements for keeping position in "line" is the exact information of the guide's course and speed. A slight error in the course not only causes an unaccountable opening or closing of distance, but is misleading as to bearing also.

Men-of-war are now fitted with gyro-compasses and pelorus stands which contain gyro-compass repeaters. The one-meter range-finders added to this equipment greatly facilitate keeping position.

In maneuvering in "line," if off bearing, it is better to be astern than ahead, because when the signal is executed to form column the ship which is ahead of bearing will require more rudder in order to head for her proper place in column. If considerably

ahead of position there is the danger of approaching too closely to the ship next toward the guide when that ship is about to take her place in column.

If a ship which is in position both as to bearing and distance forges ahead of the line or drops astern of it, she not only changes her bearing, but increases her distance as well. To regain position the speed only need be changed. If, however, she finds herself in such a position so that a change of course as well as a change of speed is necessary to regain proper station, it is well for the beginner to get on the proper bearing first, and then by small changes of course and speed rectify the distance, providing the error in station is not very great. If opportunity affords, the correct change of course and speed to regain position can be obtained by the "relative movement" or maneuvering board method. When the error in position is considerable, a definite change of course and speed as indicated by such a method removes the problem from the realm of guesswork to that of rules; although here, as in other cases of ship handling, the acceptance of theoretical solutions must be illuminated by sound judgment.

It should be observed that any change of distance in "line" requires an increase of speed, if the bearing is to be maintained, whether it be a matter of closing in toward the guide or opening out from her.

Keeping Position in the Line of Bearing.
(Other than "in line.")

Here, as in the case of "in line," it is well, if a little out of position, to correct the bearing first, and then the distance, thus using only one variable at a time. It has been explained that "in line" any change of distance on the guide requires an increase in speed, whether to close in or open out. In "line of bearing" this does not hold. In this formation, in order to close in toward the advanced flank, and at the same time maintain bearing, it will be necessary to increase speed. To open out from the advanced flank, while the bearing is maintained, requires a reduction in speed, provided the change of course in this direction does not exceed a limit which becomes very narrow when the line of bearing approaches the "in line" formation. The above increase or reduction of speed, while maintaining bearing, become greater

as the line of bearing departs more and more widely from "in line" and approaches more and more closely to column.

To Change Course in Succession in Column.

One of the important difficulties connected with the maneuvering of ships in formation arises from the uncertainty which exists in regard to the tactical diameter of any individual ship under varying conditions of weather and trim.

Turning trials, conducted in order to determine the tactical maneuvering data for vessels, are often made under conditions which do not result in the desired accuracy. Even when they are made with every care, in a smooth sea and with little wind, they give results which are standard only for similar conditions. A ship's maneuvering characteristics will vary with variations in draft, trim, wind and sea. The effect of these variations of conditions makes it impossible to say of any ship that her tactical diameter is a fixed number of yards for a fixed speed and rudder angle, and that the ship will turn in a circle of this diameter under all conditions.

In making a turn, the leader of the column should be scrupulously careful to use standard rudder angle at all times, to put the rudder over to this angle in the same period of time, and to ease the rudder and shift it always at the same point of the turn. It is particularly objectionable for the leader to swing past the new course and then have to come back to it. The leader should make no changes in revolutions during the maneuver.

The other ships in the column must adapt their turning arcs to the standard thus established by the leader, their problem being to follow around in his wake and preserve the formation as accurately as possible.

To put the rudder over at the right instant and by just the right amount calls for good judgment and some experience. Some officers believe that the difficulty here is best met by noting the instant when the next ahead begins to turn, and adding to this the time interval calculated beforehand for speed and distance. This seems reasonable, but is usually found unsatisfactory in practice, because the interval of time from the instant the rudder is put over to the instant the stern is observed to swing is not a known factor. The bearing of the next ahead, or of the second

ahead, should be helpful, but this again is not infallible. Perhaps the most satisfactory guide is the path of the ship ahead as evidenced by the broad sweep of the wake which she leaves in turning. This begins with a pronounced "kick" toward the off side, where the stern has swung at the beginning of the turn, and continues as a broad arc of disturbed water, the inside of which marks the path of the stem, the outside that of the stern. Practice will make it possible to judge with fair accuracy how far the bow of the following ship should be allowed to enter this wake before the rudder is put over. In this connection it will be well to remember that a fresh breeze blowing across will apparently carry the wake to windward, and that at night the wake cannot always be distinguished. Moreover, it is at best only a guide for turning in the wake of the next ahead, and she may have begun her turn at the wrong instant.

There is no question that the officers who are most successful in this maneuver rely upon the "seaman's eye" rather than upon any rules which could be formulated for the help of others. They, more or less, unconsciously sum up a number of factors and are guided by the balance of all rather than any one alone.

A ship well toward the rear of a long column cannot be governed directly by the maneuvers of the leader. Ordinarily she has a good view of the ships ahead, all of which, except the one which has last turned, may be assumed to have corrected any errors made in turning, and to be now following in the leader's wake. Carrying back the line formed by these ships she should be able to judge fairly well how her next ahead is progressing, and to determine whether to turn outside or inside, or to follow around as exactly as she can. Generally, it can be determined whether the ships ahead have turned inside or outside, or whether they are following in the wake of the leaders, by observing whether their stems are passing through the disturbed water, or the undisturbed water to either side of the wakes. Of course, the difficulties in following in column are enormously increased by night, when the wakes of the ships are difficult to distinguish, if they may be seen at all.

It is better to start the turn a little early rather than too late. If the bow is pushed too far across the wake of the ship ahead, it catches the current from her propellers and is thrown off still more, with the result that a small initial error is greatly magnified.

A ship which turns outside must accept the situation and straighten out on a course parallel to the column and outside of it. To attempt to work into position across the bow of the next astern, while the latter is turning, would involve danger of collision. It will be necessary, after having turned outside, to increase speed, thus making up for the larger arc transversed. Also, a ship which is turning outside has less reserve rudder available in adjusting her turning arc. On the other hand, a ship which finds herself turning inside can correct the error by easing her rudder and reducing speed, and holding this until the turn has progressed to a point where the rudder is again put over to standard for the completion of the turn. This practice is discouraged by most officers because it is likely to encourage turning decidedly inside and then easing the rudder, merely to avoid the embarrassment of misjudging the time of commencing the turn.

A ship which is turning inside will usually have to reduce speed to open her distance to the next ahead, but must resume standard speed in time to avoid hampering the next astern.

The time for easing the rudder and reversing it, to meet her on the new course, will vary with different ships. It is generally well to begin easing the rudder when about twenty degrees from the new course, and shifting the rudder when about ten degrees to go. For small changes of course the above must be modified. It is especially important for the leader to be absolutely consistent in this matter.

It is important to watch the steering after the next ahead has begun to turn, and to take care that the ship is held on her compass course and not allowed to swing off until the order is given for the turn. If the ship is off her course or swinging when the time comes to put the rudder over for the turn, a variable and uncertain factor is introduced.

Each ship before turning should note carefully what her new compass course is to be, the steersman being ordered to come to this course when the turn is begun. It is important, also, that the speed should be uniform and standard. If a ship is closing up or dropping back as she approaches the turning point, even though she orders the formation speed at the last moment, she will continue to gain or lose throughout the turn.

The marked swinging out of the stern of the ship ahead, when

turning, actually puts her across the track of the succeeding ships, and makes a rather alarming impression upon the next astern. The longer the ship the greater this effect will be. An appreciable time is required for the stern to clear the track of the vessels astern, and this combined with the loss of speed due to turning will result in the ship next astern closing in to a degree that may cause some anxiety. As soon as the next ship begins her turn her speed will be consequently reduced and the closing-in effect will be gradually overcome, and as the leading ship eases to the new course the distance will begin to open out.

In a turn of more than 90 degrees it is very dangerous to turn inside. A ship which finds herself in this position should reduce speed in the early part of the turn to avoid running up on the next ahead, whom she will presently find swinging in across her bow as the ship ahead doubles back toward the reverse course. In this situation, she should continue turning, at reduced speed, with hard-over rudder, abreast her proper place in column, but always inside of it. There will be a temptation to work back into place by easing the rudder with a resultant check in her swing which will be impossible to regain in the limited time available. And, as she approaches her place in column she will receive a "kick" from the propeller current of the ship ahead on her inner bow, throwing her more or less across the bow of the following ship, which ship, swinging as she will be with considerable rudder, is practically powerless to do anything to keep clear.

In order to turn on an arc inside that of the column, the vessel turning inside will require more than standard rudder and possibly will have to slow or stop her inner propeller. In this case, as in other maneuvers, changes of speeds should immediately be shown by the speed indicators. The next astern can, in case of danger, help to keep clear of the ship turning inside by easing her rudder.

A ship turning outside the proper path is safe but needs a material increase of speed to keep abreast of her proper position. The danger of attempting to work into place in the column is very great, and a ship turning outside should keep up as well as possible and resume position only after the next ship astern has completed her turn.

As has been mentioned before it is an accepted rule of tactics that in column a ship is better ahead of position than astern of

it. In running more or less ahead, a ship, as a rule, does not subject any other ship to inconvenience. The next ahead will not usually attempt to get out of the way, and the next astern is under no obligation to follow up. On the other hand, a ship falling materially behind her station crowds back the next astern and inconveniences all the ships astern of her. Therefore, the tolerance permitted in distance to the next ahead should be such that the actual distance will vary between the standard distance and a distance less than standard.

If too much emphasis is placed upon this rule there may be a tendency for all ships to close unduly, and result in congestion throughout the column, or a considerable part of it. There may be little danger in such a congestion if the column continues on a steady course, but if the column changes course more than a few points the danger may become serious. When a signal for such a change of course is hoisted, the natural tendency for all ships is to try to drop back to standard distance, thus producing more or less confusion; but whether they attempt this or not, the difficulties of the change of course will be much increased.

Needless to say that, upon hoisting the signal for such a change of course, the column as a whole could better execute the maneuver if the vessels in the formation would each adjust their speeds to standard, rather than attempting to open out to the full standard distance by reducing speed below standard. Of course, if too close to the next ahead to make the turn safely, such decrease of speed will be necessary.

Turning Simultaneously.

To turn simultaneously through 100 to 180 degrees is a test of ability in station keeping in formation, because any error in position, speed or rudder angle is brought out very strikingly. In one respect, the apparent result may be misleading, since the guide upon completion of the maneuver changes, and it may happen that ships which were exactly in position with the former guide and have turned perfectly are out of position relative to the new guide when the turn is completed, as a result of the new guide having been out of position when the signal was executed. In making simultaneous turns it is important that the rudder be put over at the instant of execution of the signal.

As soon as the signal is made for this or any other maneuver which involves a change of guide, each ship should endeavor to get her bearing and distance from the new guide so that she may know where she is likely to find herself at the end of the maneuver and what adjustments will be necessary for getting into position. If in position at the beginning of the maneuver the speed should be adjusted to that of the guide. Throughout the turn bearings and distances to the guide should be observed, and such adjustments during the turn as are necessary to complete the maneuver in position should be made. The adjoining ships on either hand should be carefully watched, as distances are sometimes closed rather unaccountably in a turn of this kind.

It is a fact often noted in fleet maneuvers, where vessels of different types are associated, that some ships lose much more speed than others in turning. There are several reasons for this difference. With ships of different length, but otherwise similar, the longer ship will expend a greater proportion of her power in turning, and thus her speed will fall off more than that of the shorter ship. A vessel with full deadwood aft expends more power in turning than one with the deadwood cut away, and therefore loses more speed. A ship with large turrets or other heavy weights at the bow and stern requires more power to take up her swing at the beginning and more power to check it at the end than one whose weights are more evenly distributed.

In a Fog.

Running in column formation in a fog has been simplified to some extent by the adoption of position buoys. It is well to keep the buoy of the ship ahead slightly on either bow and a little ahead, and if a change of course is to be made, on that side of the stem toward which the turn is to be made. If each ship keeps a searchlight trained aft the situation is further improved. The searchlight can be made out from quite a distance in a fog, and should be used by day as well as by night. In "line of bearing" and compound formations searchlights are of great assistance in maintaining proper interval and distance.

It is important to keep well closed up in a fog. If a ship loses touch it is difficult to regain it.

Except in case of an emergency, only small changes of course

should be made in a fog. If the course is to be changed more than 45 degrees it is better to make it in two changes, allowing time between for the ships to get straightened out.

If danger of collision with a ship outside the fleet threatens, it must never be forgotten that the other ships of the fleet are to be considered in any maneuver that may be made for keeping clear. It is as indefensible in law as in seamanship to foul a ship of the fleet in keeping clear of an outsider. In any event, the caution to remember the ships in a formation as well as the stranger cannot be amiss.

Although the subject of avoiding collision is fully covered in another chapter, attention may here be called to the difference between the case in which one ship strikes another on the broadside and that in which two ships scrape alongside. The importance of this in connection with ships in formation lies in the fact that all the ships are, in general, headed in the same direction, so that if one of them stops without turning very much, the next astern, coming up, if she cannot avoid touching, will be able, usually, to scrape alongside rather than to strike a direct blow. It may, perhaps, be suggested from this that if a ship in formation finds it necessary to back her engines to clear another vessel, she should try to avoid swinging off the course more than is necessary. The next astern, coming up, has thus the maximum chance of avoiding collision altogether, or of striking a glancing rather than a cutting blow.

It is very important in a fog to have a good lookout at the bow and to provide efficient means of communication with the bridge. This lookout will be able to see the vessel ahead, its position buoys, or other objects when they are not visible to those on the bridge.

Breakdown.

A vessel which breaks down should sheer out of column at once, and should be very prompt in giving the required signals that the ships astern may stand clear. Rules are laid down as to the side for sheering out, and as to the signals to be made.

An accident to the steering gear may make it necessary or advisable to sheer out on the wrong side. The engines may be used for steering in avoiding making a complete circle and endangering the ships in the rear of the column.

Everything should be ready for shifting quickly, without confusion, from main steering power to auxiliary or hand steering, or, if the accident does not call for throwing out the main steering power, then to shift from the faulty steering station to one that is in working order. Capable men should be stationed in the steering power room at all times ready to meet any emergency. The detail of men for the hand steering gear should be considered quite as important as the relief for other emergencies on board.

The lines of communication from the bridge to the various steering stations should be tested frequently and kept intact at all times. Frequent drills in the shifting of steering control and steering power should make it a matter of simple routine to meet emergencies connected with the steering.

Man Overboard.

In formation certain rules are laid down as to the action taken and signals made by the various ships in a formation in case of "man overboard." Except when the ships are in column, the maneuvers on the part of the ship losing the man are similar to those when acting singly and the fundamentals as laid down in Chapter XVII apply.

Getting Underway.

Notice of the hour of getting underway having been given in advance, signal is made a few minutes before this hour to "heave short," and, at the proper time, to "get underway." If the ships chance to be heading in the proper direction, and if the flagship or other ship which is to lead out of the harbor is at the head of the column, the maneuver is very simple. If the ships are heading in some other direction, they should keep this heading after the anchors are up, until signal is made to turn. All ships are required to adhere rigorously to the anchorage line of bearing while casting.

If the flagship is at the inner end and proposes to lead out, it is advisable, unless conditions of wind and tide introduce difficulties, for the ships to turn a little short of the course on which they will run out; that is to say, they should head one or two points short of the line along which the flagship will pass as she

leads out. Each ship is then headed on a course that will permit her to drop in her proper place.

It is much more common to see ships slow about getting into position than to see them closed up too far, the result being that in a fleet leaving port the leaders are often seen running at half-speed while the rear vessels are required to use full speed to close up. The reason for this is usually slowness in casting on the part of one or more vessels, or lack of smartness in taking position. Departures from shallow water anchorages are frequently delayed because of the difficulty in turning the ship in a limited space in such water.

Anchoring Simultaneously.

In standing in toward an anchorage it is customary to slow to five or six knots while still some distance away, and to stop when at a distance such that the ships will reach their berths with sufficient way through the water to give steerageway. At this point it will require considerable effort on the part of each ship to maintain her proper position, because of differences of displacements and characteristics which effect the retardation of speed in varying amounts.

In the case of approaching an anchorage, as well as any other time in formation, when the speed is very low and the ship is out of position, it should never be attempted to regain position with small changes of revolutions. The change should be radical for a short period of time in order that the ship regain her station promptly.

All ships should anchor simultaneously, the instant the anchorage signal is executed. It is not considerate to the next vessel astern to continue on to make up lost distance when he has properly obeyed the signal. If it is necessary, request permission to shift berth after anchoring.

Some Duties of the Officer of the Deck.

In concluding this chapter it may be helpful to call attention of young officers to the magnitude of the responsibility which rests upon an officer in charge of the deck of a man-of-war at sea. Officers easily become so accustomed to the routine of

cruising and maneuvering without accident that they forget how close they may be at any instant, not only to accident, but to disaster.

It is not alone the mishaps of one's own ship which must be considered, but those occurring to the ships ahead as well. It is true that if the next ahead stops her engines suddenly because of accident she still holds her way for a time, and if the officer on her bridge is alert and self-possessed he will give instant notice of her "breakdown" and will sheer out of column. If the next astern is also alert and self-possessed, he will see the signal instantly and will act accordingly, and the danger will not be great. The same is true of other accidents, such as failure of the steering gear, "man overboard," or any unexpected maneuver to avoid a vessel or other danger suddenly discovered ahead.

But suppose the officer on the bridge of the ship ahead is slow to act, and in addition to this, neglects to signal that anything is amiss. If now the officer on the bridge of the next astern is alert as he should be, and ready to recognize and meet the situation, all will still be well; but if he is giving his attention to other things, perhaps studying the chart, or engaged in something less justifiable, he may lose the brief interval in which he would have time to act, or may be forced to act so quickly that his judgment is at fault, and it may be his lot to become responsible for a serious accident.

While cruising in formation it is well to remember that upon stopping the engines of a turbine-drive or electric-drive ship the propellers will continue to revolve as the ship continues to make way through the water. On the other hand, when a ship with reciprocating engines stops her engines the propellers cease revolving almost immediately and act as a drag. It follows that in formation, upon executing a signal "to stop," a turbine-drive or electric-drive ship will close her distance rather rapidly if the ship ahead has reciprocating engines.

In handling a turbine-drive ship it must always be kept in mind that the power for backing her engines may be as low as only half the power available for going ahead because of the relatively small size of the backing turbines. In emergencies the rudder of the turbine-drive ship will have to be relied upon more than with reciprocating or electric-drive ships with their greater power for backing.

It is perhaps essential that matters of internal routine should make some demand upon the attention of the officer of the deck at sea, but these demands should be reduced to a minimum, and should never for an instant cause him to forget the vastly more important duties connected with the safety of the ship. There should at all times be some responsible person on the bridge who is closely watching the movements of the ship ahead. If, therefore, the attention of the officer of the deck is for a brief time necessarily diverted to something else, he should caution his assistant to concentrate his attentions on the ships ahead.

It should be thoroughly understood in every ship, whether she is in company with a fleet or cruising singly, that her own officers are always responsible for her safe navigation. Therefore, when in column in cramped waters, the leader should not be followed blindly, under the supposition that because he passed foul ground ahead safely the vessels astern are bound to do the same. There are generally certain conditions of tide, wind and current to consider. It is sometimes remarkable how much the end of a long line of ships may be deflected from the course by one or a combination of these conditions.

It is well to prepare oneself for prompt action by frequently picturing the emergencies which may arise and deciding upon the proper methods of meeting them. This habit, coupled with the vigilance which will result from recognition of the fact that the emergency, if it is to come, will come without warning and when least expected, will give the only assurance of readiness to meet it with credit.

One of the unfortunate features of an officer's preparation for his duties is that very few emergencies can be simulated, with their attendant features of danger and surprise, for purposes of training. The situation, for example, in which a vessel suddenly appears in a dense fog close aboard, requiring instant decision as to the actions required to avoid collision, is one in which no officer can hope for much practice, except in his own mind. And so it is with innumerable other situations.

Much is gained by making sure that all emergency equipments are in working order, and that men stationed to operate them are thoroughly familiar with their duties; that the breakdown flag is rounded up to its place; that the signal gun is manned and ammunition at hand; that prescribed pyrotechnics are in

their appointed place; that the life boats are ready for lowering, the crews are mustered and stationed; that all preparations are in order for shifting of steering control stations, for shifting of steering power and for steering by hand; that a position buoy is ready for use if there is a possibility of fog, etc.

While requiring lookouts to be alert, an officer should not rely on them entirely. The officer of the deck is his own best lookout, and if he sees danger first, he gains time which may be vital in avoiding it.

In the matter of tactical signals it is a good rule to verify them by reference to the Signal Book or other memoranda in which the most important signals are set down. The meaning of certain often used "direct-reading signals" should be known without such verification. It is important to note whether neighboring ships have apparently read the signal correctly and are starting out to perform the maneuver properly. A mistake made by any one ship may be more dangerous to others than herself.

When a ship is ordered to leave a formation for some particular mission, she should make a decided change of course to show definitely that she is leaving.

In joining a formation the maneuvering board is used to determine the course and speed required to reach the proper position. It is best to approach the position on such a course that when swinging into place an abrupt change of course will not be required. The maneuvering board is used to reach the near vicinity of the place in the formation. The final adjustments of course and speed as the ship is placed in her proper position depends more on the "seaman's eye."

The officer of the deck should never enter the chart room at night except in case of necessity. To do so not only takes him from his proper station, but affects his eyes in such a way as to render them useless for an appreciable time after he comes out.

The engine room should be notified in advance of any appreciable change in speed, and the length of time, when practicable, such a change will be in effect.

It must be remembered that the Rules of the Road are always in force, and that when cruising in formation and also when ships are darkened, exceptional vigilance is required. When cruising darkened, ships must keep clear of vessels that are lighted, and

be ready to turn on their lights immediately in case of a situation which may involve risk of collision.

Tactical exercises afford excellent opportunities for those conning the ships to demonstrate their regard for good "sea manners." Consideration for others not only expresses the spirit of an organization, but also makes for higher efficiency. If by giving way a ship can ease the situation for another, the maneuver as a whole will generally be better accomplished.

CHAPTER XVI.

TOWING.

The Towline. Generally speaking, the longer and heavier the towline used, the easier the towing will be. A decided dip or catenary gives the same advantage here as in the case of a vessel at anchor riding with a good scope of chain. The catenary acts as a spring, preventing variations in the tension from being thrown upon the towline in sudden jerks. The sag of the bight depends not only on its length but also on its weight. The dip does not in the least reduce the tension of steady towing.

Wire rope has proved very satisfactory for heavy sea towing. It is true that it does not have the elasticity or spring of manila, but this disadvantage may be overcome by the judicious veering of the chain cable to which the wire rope may be secured or by using a towing engine.

The advantages of using wire rope are that it is more convenient for casting off, takes up comparatively small space when stowed, and does not deteriorate if properly dried and oiled before stowing.

Manila is the most satisfactory line that can be used for light or moderate towing. It is heavy enough to give a good dip when used in sufficient length, but it is not too heavy for convenient handling. Its buoyancy is a distinct advantage, particularly where lines are to be hauled over considerable distances.

A good plan is to combine manila and wire, the towing vessel first paying out the manila hawser, which is hauled across by the tow and secured, after which the towing ship shackles the wire rope to the manila and then starts ahead very slowly, paying out the wire rope as she gathers way.

For towing a vessel even as small as a 1215-ton destroyer in rough weather—and it must not be overlooked that rough weather may be encountered in almost any towing operation—the full length of an eight-inch manila hawser or a one and one-half inch diameter wire rope will be none too much.

Where the tow is a vessel whose displacement is comparable with that of a battleship, the towline should be made up of two or two and one-quarter inch diameter wire rope connected to a good length of her own anchor cable.

The length that is needed will vary with circumstances, but it is far better to have too much than too little; and the use of a margin of safety which seems unreasonably large may result in a very comfortable security from the vexatious accidents and delays which are all so common in towing.

A point of some importance in towing in a seaway is to keep the ships "in step"; that is, to use such a length that they shall meet the waves and ride over them together. If the length of the line is such that one vessel is in the trough of the sea as the other is on the crest, the line will for a moment slacken, then tauten with a sudden jerk; whereas if they meet the waves at the same time the tension on the line will remain comparatively steady. The wave lengths of a sea are usually approximately uniform at any given time, and it should not be difficult to control the length of the line by heaving in or veering away the anchor cable on the tow. In towing for a long time and covering a great distance, extreme variations may of course be found in wave lengths, and the inconvenience of changing the length of the line from time to time may more than offset the advantage to be gained; but it is worth while to recognize this point and to be ready to take advantage of it when circumstances permit.

Securing on the Towing Ship. In securing the towline, consideration must be given to the possible necessity for letting go in an emergency. It is clear that there are many emergencies which may arise in which the line must be cast off in the shortest possible time; such as a sudden threat of collision. This is a point which is not always given the consideration to which its importance entitles it.

For convenience in letting go, it is desirable to have a break in the line near the stern; that is to say, to have, at or near this point, a shackle connecting two parts of the line, together with some arrangement, like a pelican-hook, for slipping quickly. The possible "whip" of towlines and bridles when released at any point well inboard may be overcome by the use of preventers.

To have the end only just inside the stern chock on the towing ship means that practically the whole length of the towline must

be paid out, and that any variation in the length must be taken care of by the tow. As it happens, this is usually the simplest way to arrange matters, provided the anchor cable of the tow is in use as a part of the towline. It is very easy to heave in or veer away on this, as may be necessary for shortening or lengthening the towline.

If the towing ship is comparatively large and has a chock at the stern and amidships, the line should be brought in through it. It is a good plan to use a short length of chain for the lead through the stern chock, shackling outside to an eye in the end of the towing hawser and inside to a towing bridle from the turret, after gun foundation, or elsewhere, depending upon the arrangement used for securing. The chain through the stern chock not only takes the chafe but by its flexibility does away with the dangerous "nip" which might be thrown into wire if the tow chanced to take a rank sheer onto the quarter.

Where the chain is not used for taking the chafe in the stern chock, the towline must be fully protected by chafing gear, which should be put on in the shape of a long and bulky "puddening." The stiffness of such a puddening reduces the sharpness of the nip, which without it, would be thrown upon the towline from time to time by the sheering of the ships.

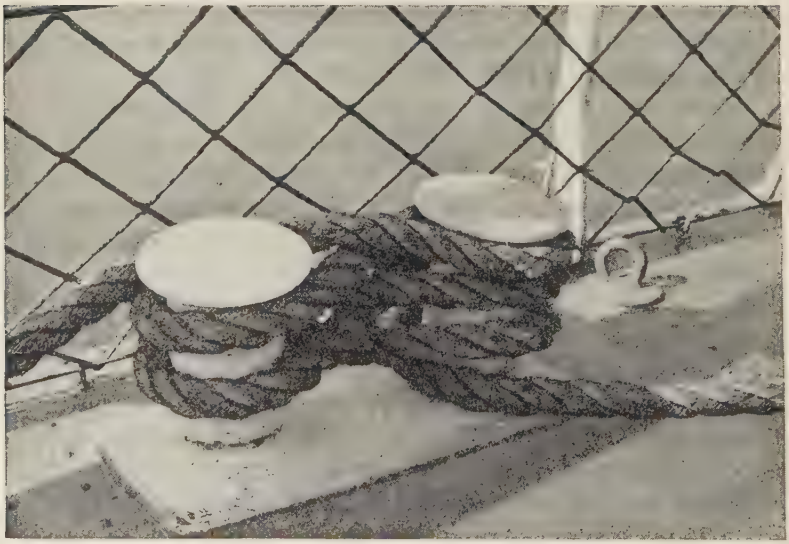
Where the strain is not too heavy to be taken by the bitts, the arrangement may be similar to that shown in Plate **149a,** the line being taken around as many sets of bitts as are available. To divide the strain here, it is advisable to take only one or two turns around the first bitts, thus leaving the line free to render slightly and so transfer a portion of the strain.

Figure 1 represents how a towrope should *not* be secured. Here the greater strain comes on the forward bitt, which might result in the bitts lifting from forward, and being torn out.

In Fig. 2 the greater strain is taken by the after bitt, and though the forward bitt has some, they should hold under ordinary conditions.

Where pelican hooks are used for letting go, as shown by Plate **150**, the strain is taken momentarily on the hook, relieving the shackle so that it can be disconnected and towing hawser slipped when ordered. This arrangement entails practically no delay. An arrangement with a pelican hook taking the steady

Lead to Tow. The Wrong Way to Secure a Towrope, Fig. 1.
(Direction of Tow →)



Lead to Tow. The Right Way to Secure a Towrope, Fig. 2.
(Direction of Tow →)

PLATES FOR SECURING TOWROPES TO BITTS.

strain of towing offers the quickest means for effecting an emergency release.

Where pelican hooks are not used, a strap may be used on the wire or chain, outside the shackle, and a heavy purchase hooked to the strap and taken to a winch. For letting go, the strain is taken by the winch long enough to disconnect at the shackle, after which the strap is cut as ordered (Plate **150**). A preventer similar to the one shown in Plate **158** must be used to prevent a dangerous whip upon letting go.

There are some conditions under which it is convenient to use a span on the towing ship, the two parts being brought in through the quarter chocks. Generally speaking, this makes it rather easier for the towing ship to steer and the advantage gained in this respect may become important in cases where a small ship is dealing with a heavy tow. Where the line leads from a chock directly over the rudder, it binds the stern so that it can only swing in obedience to the rudder by dragging the tow with it. A large ship can take care of this situation by the power of her steering gear, assisted, if necessary, by the propellers; but a small ship with a heavy tow and with the line leading through the stern chock, will steer very sluggishly if she steers at all. Tugs which are specially fitted for towing have their bitts well forward of the rudder, allowing a chance for the stern to swing; the fittings abaft the bitts being such as to let the line sweep freely across from one quarter to the other.

Where a span is used it may be of chain, wire, or manila. In this, as in other cases, arrangements must be made for letting go quickly in emergencies.

A convenient plan is to bring the towline in through a quarter chock and bend a hawser from the other to it at such a point outside that the two parts shall form a span of convenient length. The lines may be secured around bitts as previously described. This plan has the advantage that by letting go the second line we get rid of the span at once and have to deal only with the towline itself.

Vessels designed especially for towing are in most cases fitted with towing engines, which carry the towline on a reel and pay out and haul in automatically as may be necessary to keep the towing tension constant. If the tension on the hawser rises momentarily, the drum revolves and pays out the line. If, later, the

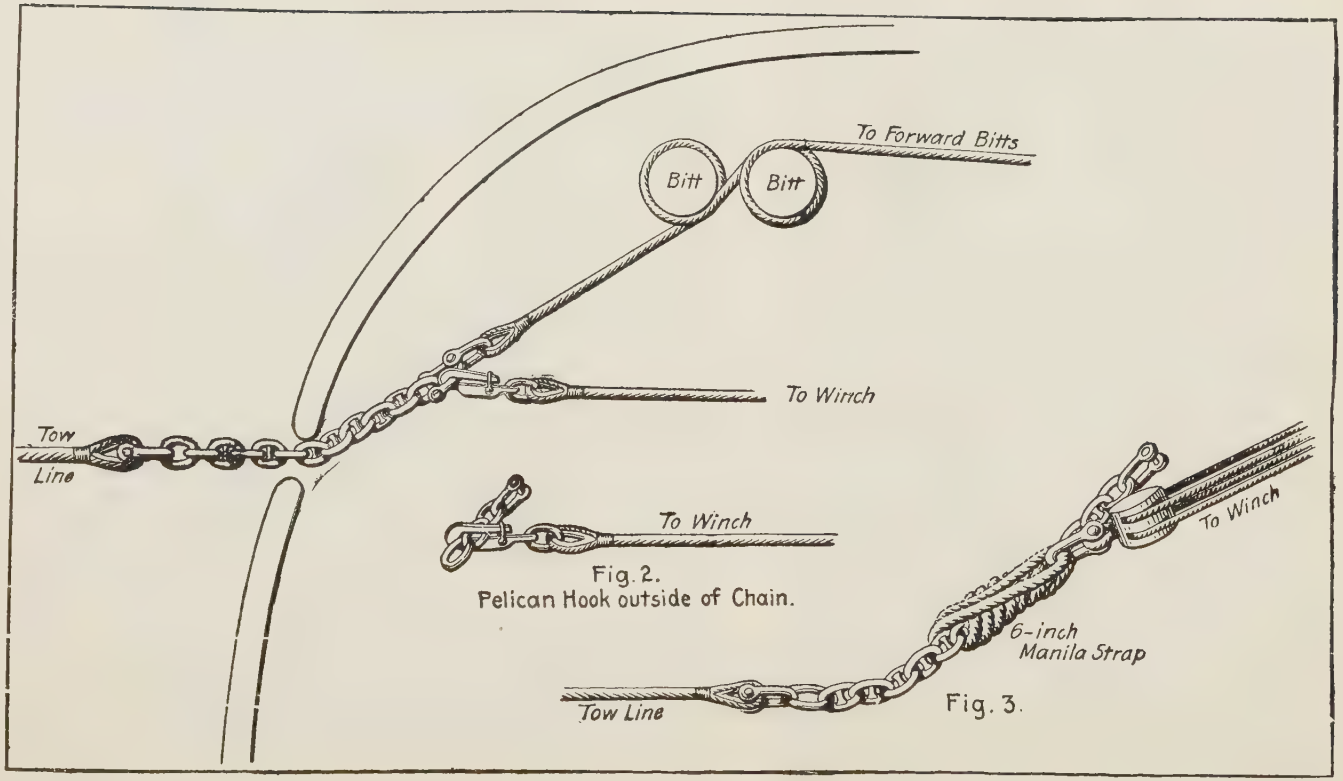


Fig. 2.
Pelican Hook outside of Chain.

Fig. 3.

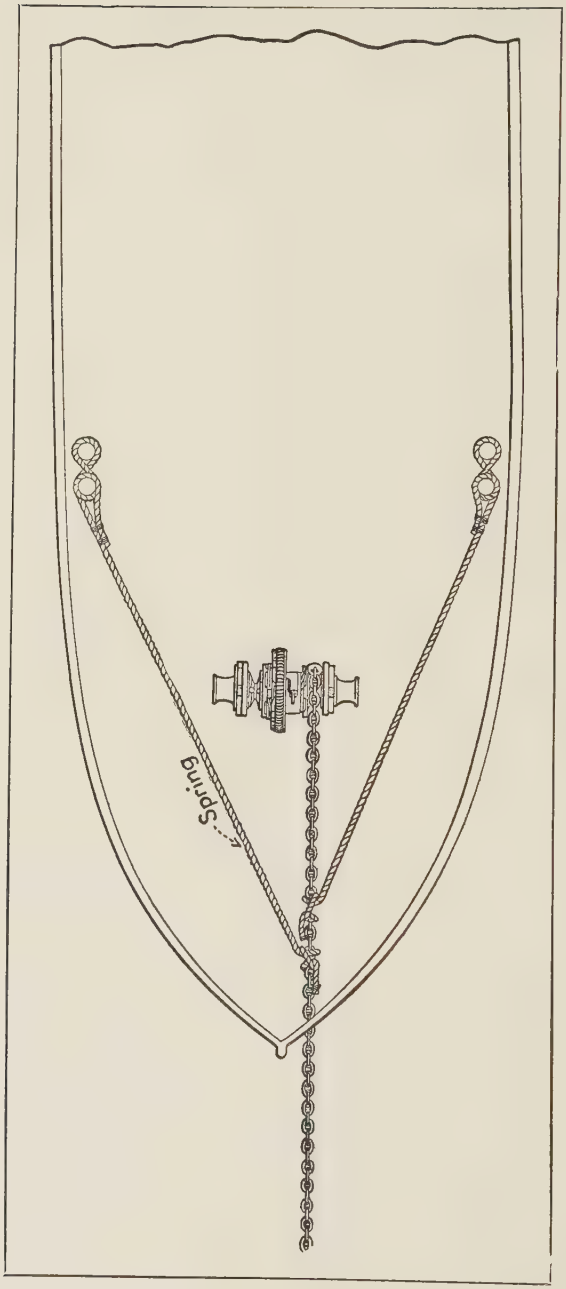
TOWING BY BITTS.

tension decreases, the drum will revolve and reel in the line. In this way, the line is paid out or reeled in only just enough to meet the condition prevailing at any given moment, and the average length of line remains practically constant.

The function of a towing engine is twofold in that it provides power for lengthening and shortening the hawser, and it adds elasticity to the hawser. There can be no question of the great advantage in towing resulting from its use. A point of great, though perhaps secondary, importance is that if the towing vessel stops, or if for any other reason the tow ranges up and slacks the line, the towing engine takes in the slack at once and keeps it clear of the propellers. If it is found desirable at any time to vary the length of the line, it can be done without difficulty This may be important in passing around bends in a channel, or for taking in the line preparatory to casting off.

On Board the Tow, the hawser is usually secured to the anchor cable, although there may, of course, be many conditions under which some other arrangement will be provided. If the anchor cable is not used, it is desirable to use at least a short length of chain to take the chafe in the chock in the same manner as already described for securing on the towing ship. If even this is impracticable, abundant chafing-gear must be used, and this should be examined several times a day and renewed as often as may be necessary.

Where the anchor cable is used, the hawser is secured or shackled to it and the cable veered away to the desired length, after which the windlass brakes are set up and springs or chain stoppers are used to take the real strain of towing as in Plate **151**. It is well to have a shackle between the windlass and the point to which the springs or chain stoppers are secured and to keep tools at hand for unshackling if it becomes necessary to let go in an emergency. Generally speaking, however, the tow should not let go in this way except in case of extreme emergency, as the line, weighted with a considerable length of heavy anchor cable, would sink immediately, hanging as a dead weight from the stern of the towing vessel, where it would be extremely difficult to handle and would be in danger of fouling the propellers. This applies only to cases where the tow is a vessel of some size, and where she is towing by her anchor cables. It is evident that where a large ship is towing a small one, the natural way of



BOW OF SHIP TOWED.

casting off is for the tow to let go, leaving the line to be handled by the large ship. There is here, however, no question of a heavy anchor cable hanging from the end of the line.

In the more general case where the anchor cable of the tow is in use, the natural way to let go is for the tow to heave in her anchor cable and then cast off the towing hawser.

There may, of course, be cases where the towing vessel is the proper one to let go, leaving the tow to handle the whole of the line. Cases may arise in which both vessels must let go, sacrificing the line to avoid some serious danger.

It is well to remember that in an emergency the towing vessel may safely back her engines without letting go the line and without danger of fouling the propellers; but this must not be continued long enough to check her headway altogether—much less to let her gather stern-board—as to do this would involve danger not only of getting the line into the propellers, but of being rammed by the tow. On the tow, the steersman should always be alert and ready to sheer out in case of ranging up onto the towing vessel.

Taking a Disabled Vessel in Tow at Sea.

In good weather, this maneuver presents no especial difficulty and calls for no extended discussion. The lines are run and secured as already described. The towing vessel starts ahead slowly on the course upon which the disabled vessel happens to be heading, using every precaution to prevent a jerk on the line, and waiting, before changing course, until both ships have gathered way and are moving steadily with a good tension on the towline.

In very bad weather, on the other hand, towing should not be attempted unless exceptional circumstances make it necessary; as the running of lines in a heavy sea is attended by considerable difficulty, especially if the vessel to be towed is unable to assist by placing herself in a favorable position. Moreover, in really heavy weather, it would be necessary to proceed so slowly that little or no time would be lost by waiting for the weather to moderate.

It will be considered, in the discussion which follows, that the weather is rough enough to call for the use of all reasonable

precautions, but not rough enough to make towing impracticable. It may be assumed that the disabled vessel will be lying with wind and sea a little abaft the beam—this being the position which a steamer usually takes up when lying in a seaway with engines stopped. The other vessel places herself on a parallel heading, either to windward or to leeward. In considering which of these positions is to be preferred, we must remember that considerable time will be required to run the lines; and that, during this time, both vessels will be drifting at a rate which may make their drift a very important factor. A vessel which is light will drift faster than one which is loaded, the drift of a vessel in ballast-trim amounting often to several knots. If the lighter vessel is to leeward, she will drift away from the other, making it very difficult to run the lines. It may be said, therefore, that as a general rule, if there is any important difference in the rate of drift of the two vessels, the lighter one should be to windward when the work of running the lines is begun.

If there is any doubt as to which vessel is drifting the faster, this can be determined by placing the one which is able to maneuver in line with the other and on the same heading.

The towing vessel, then, places herself to windward, if she is drifting faster than the other vessel, and to leeward if she is drifting more slowly, and on the same heading as the disabled vessel; taking care, of course, not to run any risk of drifting into collision, and remembering, as the ships draw together, not to get so close that the rudder cannot be put over for hauling off without danger of throwing the stern into collision with the tow.

Where the difference in the rate of drifting is considerable, the time available for running the lines after the work is once begun will be short at best and every precaution should be taken to prevent delay; a clear understanding being established between the ships and all preparations made, before the towing ship takes her position. In communicating between two ships, megaphones are of the greatest value. Under any except the most unfavorable conditions, they should make it possible to perfect a thorough understanding of what is to be done and how. They also may take the place of signals, to a great extent, between the two ships after the towing begins, although a code should by all means be adopted and will be useful under many conditions. It

is an excellent plan, when feasible, to send an officer on board the tow to remain there permanently; acquainting him first with the plan to be carried out and providing him with a list of whistle and sight-signals for handling the lines and the ships. If no boats are to be used, a paper may be floated across to the tow, giving full instructions and a list of the signals. This may be sealed up in a bottle and attached to the rope or the float. Whistle signals are preferable to flags, because they can be used at night or in a fog.

The following is suggested:

Code of Sound Signals for Towing.

A short blast must not exceed two seconds in length.
A long blast must not be less than six seconds in length.

I am putting my rudder right	1 short blast.
I am putting my rudder left	2 short blasts.
Go ahead	2 long.
Stop	1 long, 2 short.
All fast	2 long, 1 short.
Haul away	2 short, 1 long.
Let go	2 long, 5 short.
Pay out more line	1 short, 2 long.
Avast hauling	3 short.
I am letting go (emergency)	5 short, 5 short, 5 short.

The first line to be run will be a light one, by means of which the heavier ones can be hauled across. A three-inch manila is a convenient size to begin with. If new, so much the better, as it will float freely. If a boat is to be used it should be lowered with the crew and the greater part of the line in it, and got clear as quickly as possible, the line being paid out as the boat pulls away for the other ship.

The line may be floated alongside the disabled ship without much difficulty. The best way to do this will depend upon circumstances, but a common way is to float a good length of the line by life-belts, casks, or any other means, and to steam slowly around the disabled vessel, dragging this astern and causing it to foul the disabled vessel. If proposing to take up a position on her weather bow it is a good plan to steam along to leeward,

fairly close aboard, cross the stern, and come around parallel to her heading. This will cause the line to foul her stern, which entails a little trouble in shifting it forward, but it leaves the towing ship in position without further maneuvering. Similarly, if proposing to take a position on the lee bow, pass along to windward, cross the stern and come around to leeward. The line should be picked up without difficulty.

Many vessels are provided with guns throwing a line-carrying projectile. These are very useful and may save a great deal of trouble and delay. For moderate distances the Lyle shoulder gun is generally used. (Plates **152** and **153**.) For greater distances three- and six-pounder saluting guns with line-throwing equipment may be similarly employed on naval vessels.

An ordinary ship's rocket affords another and an excellent method of establishing communication. Such a rocket will carry a small fishing line over two hundred feet athwart the wind. If proposing to use this method, it will be better to go to windward and as close as is prudent. The fishing line is faked down on deck, clear for running, with one end fast on board and the other bent to the rocket stick a few inches from the end. The rocket is given a good elevation (about 45°) and fired. If connection is successfully made, a somewhat heavier line is bent on and hauled across and so on until a sufficiently heavy one has been run to haul over the towline. If the wind is blowing across, it will carry the bight of the line, and hence the tail of the rocket, to leeward, causing the rocket to work up to windward. Allowance must be made for this.

There may be special circumstances which will make it desirable for the disabled vessel to run lines, but under ordinary circumstances it is more convenient for the towing vessel to run them. Having got the first line across, by whatever method, the heavier lines are run and made fast to the anchor cable of the vessel to be towed, where possible. A good length of cable is paid out—twenty to forty-five fathoms is none too much for heavy work—and the line made secure on both ships as has been described, chafing-gear being used liberally wherever it can be needed. In the meantime, full instructions about starting are given to the chief engineer, and when all is ready the engines are started ahead as slowly as possible, and stopped the moment the line begins to tauten out; then a few more turns are made,

LYLE LINE THROWING GUN, SHOWING GUN, CARTRIDGE, PROJECTILE AND LINE.

and so on until the inertia of the tow is overcome and both ships are moving slowly with a steady tension on the line. The revolutions are then increased little by little and the course changed gradually, as may be necessary. When, finally, the tow is straightened out and moving steadily, the speed is worked up to that at which it is thought wise to continue.

Plate No. 153

PLATE SHOWING LYLE LINE THROWING GUN.

In all changes of course, the tow puts her rudder at first to the side opposite that of the leader, and so steers around into the leader's wake.

If the sea is such as makes it dangerous to tow to windward, it is worth while to consider whether a port cannot be made on a course which will present fewer difficulties, even if the distance is much greater.

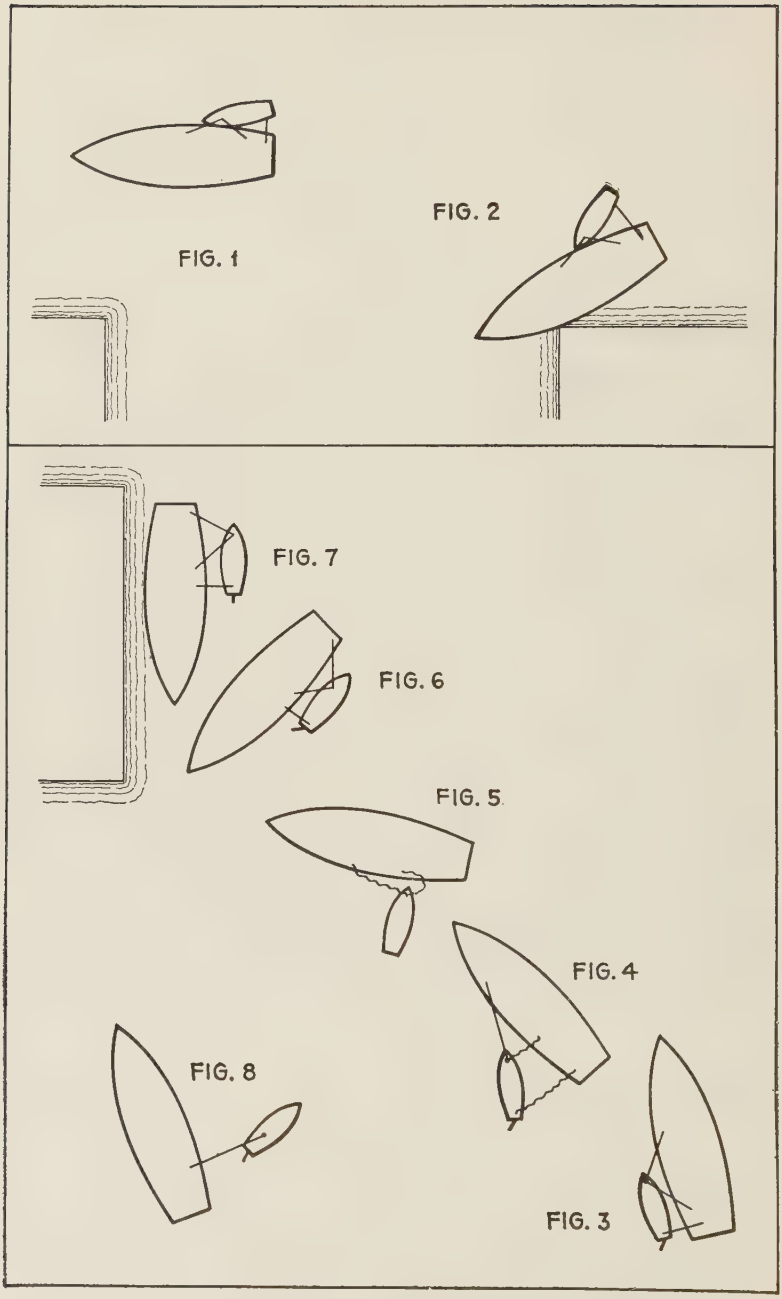
After settling down to a steady rate of towing, the lines should be examined, the strain divided as evenly as possible, chafing-gear renewed wherever necessary, etc. Hands should be stationed night and day to watch the lines on both ships, with axes and unshackling tools ready for slipping hurriedly, if necessary. It is well to have a light "messenger" line between the ships, for hauling messages across and for use in running a new line in case of necessity. This line should be left slack and should have ample length to allow for the fact that if the towline parts the leading ship will forge ahead considerably before she can be stopped.

Towing Alongside. When towing in port or in confined waters, the tug should be made fast alongside if possible, as this gives greater ease and certainty in handling. When used in this way, the tug is usually placed on the quarter, where its rudder acts with that of the tow, for steering. As the power is applied at a distance from the midship line, there is here a considerable turning moment, which will throw the ship's head to one side or the other, according as the tug goes ahead or backs; the effect being exactly as if the tow had twin screws and was using only one of them. In going straight ahead, the turning effect is neutralized by a small amount of rudder.

The tug should be secured well aft alongside of tow with her bow snubbed in towards the tow with a line from aft for going ahead and one from forward for backing. These lines are usually made fast at the bow of the tug, her stern being held from swinging out by an after breast leading to the tow. (Fig. 1, Plate **154**.)

If the tug has a right-handed screw, she will be able to make a straighter sternboard if secured on the port side; since in backing, the tendency of her screw is to throw her stern out to port, while the tendency due to her position on the port side of the tow is to throw the stern of the tow the other way. When secured on the starboard side both these elements will tend to throw the stern off to port.

If, however, there is a sharp and difficult turn to be made, the tug should be on the inboard quarter, that is to say, on the side toward which the turn is to be made. Here she will be properly placed for backing to assist in the turn. So long as she is going ahead, she would be more favorably placed for turning, on the outboard side; but if her turning effect when so placed should



TOWING ALONGSIDE—TURNING A TOW.

prove insufficient for the turn she would be helpless. To back, under these circumstances, even for keeping clear of the beach, would only make matters worse. It is the practice of tug masters to place themselves on that side of the tow toward which they wish to turn, if the turn is one which involves some difficulty.

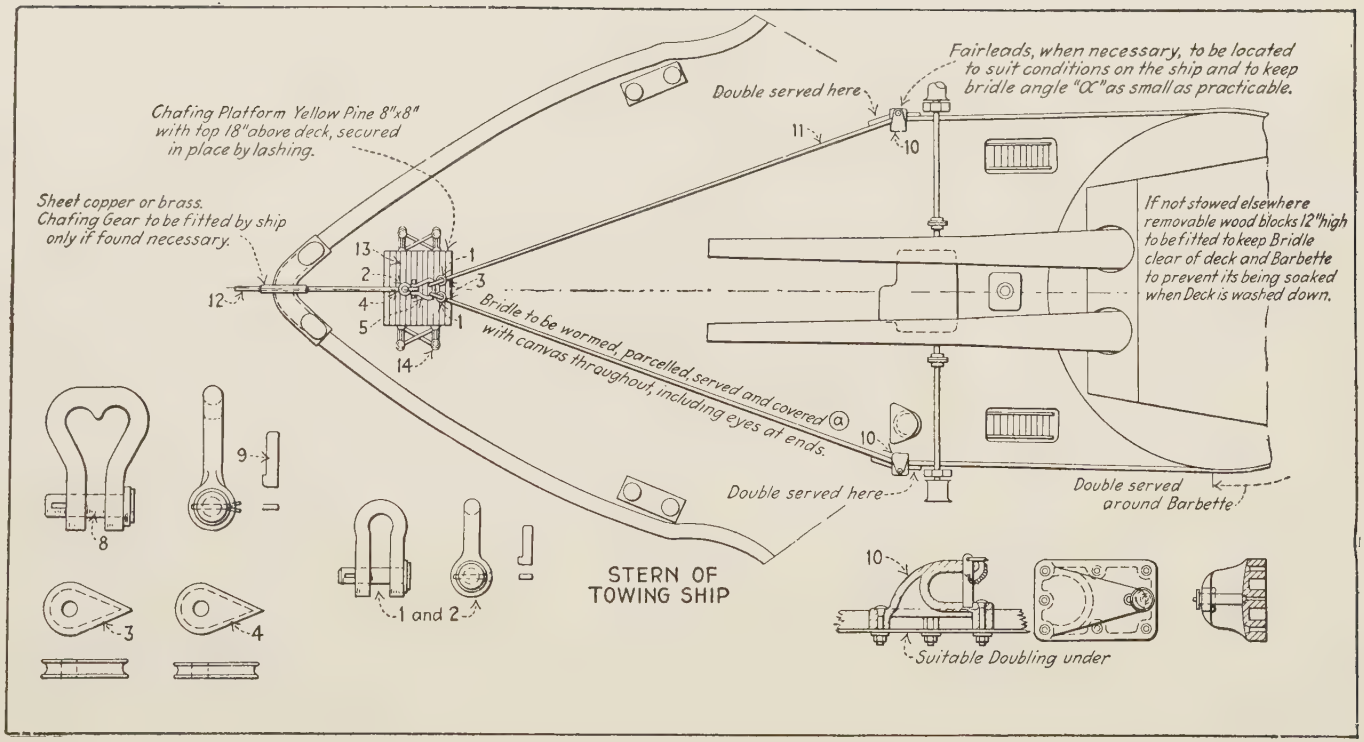
It frequently becomes necessary to turn a large vessel on a pivot. Suppose the tug is on the starboard quarter and wishes to slew the stern of the tow to port. She lets go her after breast and goes ahead with left rudder, holding the "go ahead" line. This throws the tug's stern out and she puts her bow (invariably protected by a good fender) against the stern of the tow and pushes it around.

If it is desired to pull the stern to starboard, she lets go her lines from her bow, slacks the after line, and swings off clear, going ahead as in Plate **154**, Fig. 8. Observe that for this maneuver it is necessary that the line used for towing should lead from a point far enough forward of the rudder to allow the tug's stern to swing freely. She will then be able to head in any direction desired, even though there may be a current setting her down.

A tug towing a vessel alongside oftentimes has occasion to "*wind*" the tow for putting her alongside in a particular way, or for getting on the off side in landing, to avoid being jammed between the tow and the dock. (Plate **154**.) The tug first gives the tow a sheer with the rudder (Fig. 3). She then backs, slacking all lines except the backing line (Fig. 4), then, a little later, slacks everything and puts her stem against the stern of the tow and goes ahead, pushing the stern around (Fig. 5); and ends by making fast alongside with her bow toward the stern of the tow (Fig. 6), and with her port side to the tow instead of the starboard side as in the beginning. This maneuver may be seen every day in New York harbor, where tugs handling scows have to get on the off side of the scows for landing the scows alongside while themselves keeping clear.

Standard Towing Equipment for Battleships, United States Navy.

All battleships of the United States Navy carry the Standard Towing Equipment shown in Plates **155** and **156**.


Fairleads, when necessary, to be located to suit conditions on the ship and to keep bridle angle "α" as small as practicable.
Double served here
Chafing Platform Yellow Pine 8"x8" with top 18" above deck, secured in place by lashing.
Sheet copper or brass. Chafing Gear to be fitted by ship only if found necessary.
If not stowed elsewhere removable wood blocks 12" high to be fitted to keep Bridle clear of deck and Barbette to prevent its being soaked when Deck is washed down.
Bridle to be wormed, parcelled, served and covered with canvas throughout, including eyes at ends. (a)
Double served here
Double served around Barbette
STERN OF TOWING SHIP
1 and 2
Suitable Doubling under

STANDARD TOWING GEAR, U. S. NAVY.

The approved method of taking a battleship in tow is as follows:

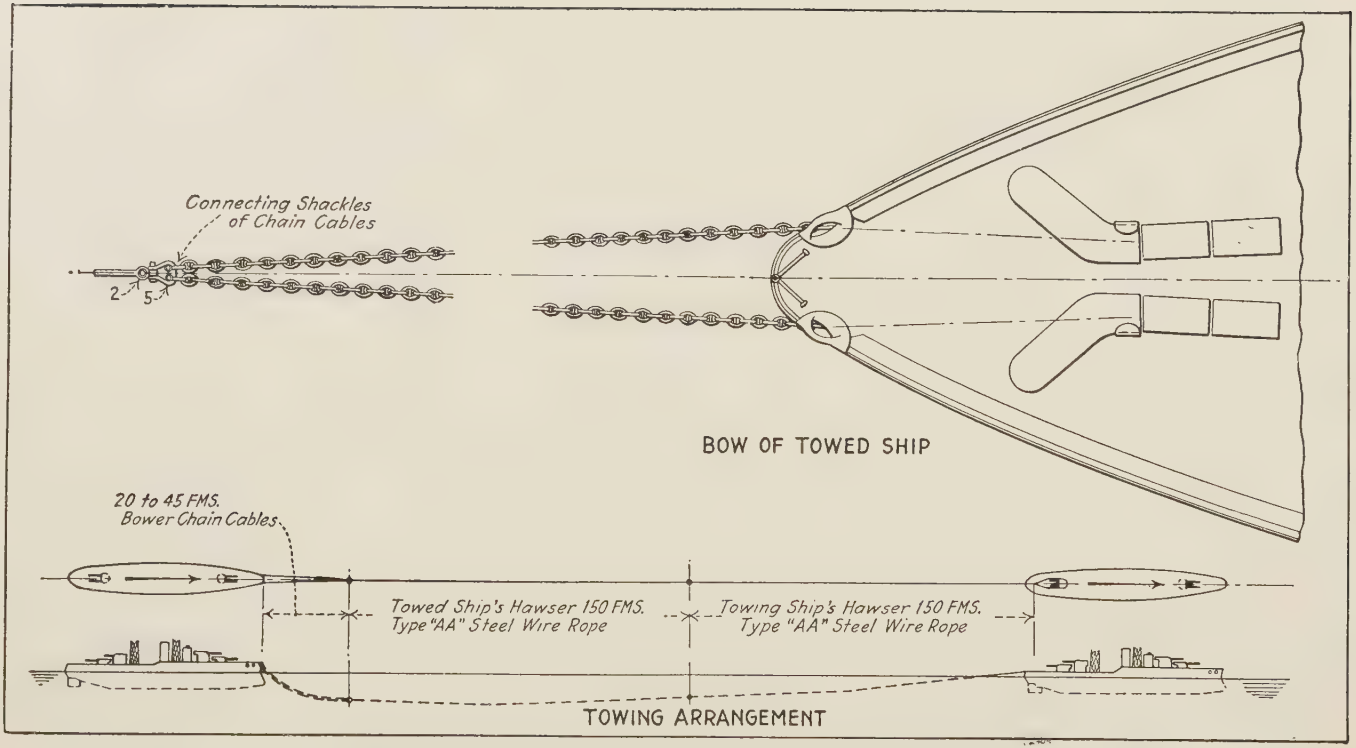
Directions for Towed Vessel. Unshackle both anchor cables at the five-fathom shackle, each anchor having first been secured by two housing-stoppers on the five-fathom shot. Reeve the free ends of the anchor cables out through the towing chocks, bring them in on the forecastle and shackle them together, forming a bridle, taking care to have all clear for veering the bridle outside when ready.

Shackle outboard of all, the end of the steel towing hawser to the bridle and fake the hawser on the forecastle, clear for running. Remember that the end which is shackled up to the bridle will go out last. Put check-stoppers of one-inch manila on the bights of the towing hawser to check it when it is payed out.

Bend a three-inch manila line to a spar. Put the spar overboard and pay out the line. The spar will probably drift to windward; or, what amounts to the same thing, it will drift to leeward more slowly than the ship.

Directions for Towing Ship. Take position about one-half mile astern of the ship to be towed, and a little to windward. Secure the bridle around the turret. Fake down the towing hawser (2¼-inch diameter wire), shackling one end to the bridle and the other to an eight-inch manila hawser, this hawser being also faked down clear for running. To the free end of the eight-inch manila hawser bend one end of a three-inch manila line which has been led aft from the forecastle, outside of all, and in through the stern towing chock.

All being ready on both ships, the towing ship steams slowly up to the spar,—the location of which is signalled by the towed ship—picks it up (on the forecastle) and bends the three-inch manila line which the spar has floated across, to her own similar line leading from aft. The bight of the three-inch line is then thrown overboard, and the towed ship takes in the slack. When the line is clear of the screws of the towing ship she maneuvers to gain a favorable position, the three-inch line being payed out as is found necessary by the towed ship. When a favorable position has been attained, the towed ship hauls in the three-inch line, followed by the eight-inch, and finally by the end of the steel wire towing hawser. The two hawsers are shackled together, and payed out. When the chain bridle is reached (on



BATTLESHIP STANDARD TOWING GEAR, U. S. NAVY

the towed ship) it is payed out carefully and the two anchor cables are veered away to whatever scope is considered advisable. Twenty to forty-five fathoms is recommended.

The tauter the line can be made before the towing vessel starts her engines ahead, the better it will be. She will of course start as slowly as possible, and, having overcome the inertia of the tow, work up, a fraction of a turn at a time, to the speed required. In gathering way at the very beginning it is well to give a few turns ahead, then stop the engines, then give a few more turns and stop, and so on.

Method Used to Release Towlines When Battleships are Towing.

The towed ship should heave in the towline *first*; heave in anchor cable used for bridle and then using two winch drums and two six-inch manila lines, bending them alternately to the wire towing hawser and stopping the bights. When the towed ship's towing hawser is aboard the tow, unshackle the towing hawsers then make fast the towing ship's eight-inch manila hawser to her own wire towing hawser and ease away. The towing vessel now similarly heaves in its wire towing hawser followed by its eight-inch manila hawser messenger.

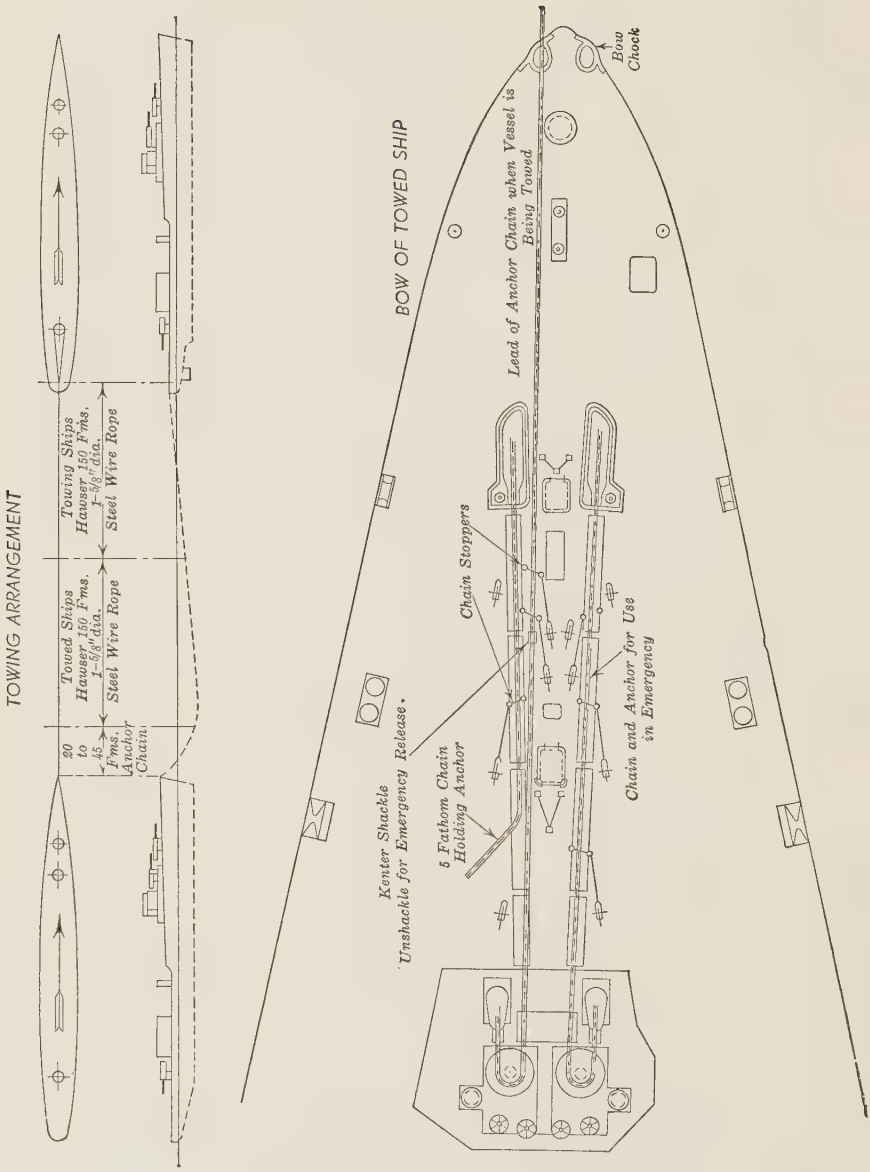
STANDARD TOWING EQUIPMENT FOR HEAVY CRUISERS, U.S. NAVY.

The arrangement for securing the towing hawser is shown in Plates **157** and **158**.

For Towed Ship. The towing hawser (1⅝-inch diameter steel wire, length 150 fathoms) is shackled to one anchor cable outboard of everything and faked down on deck clear for running (bights stopped). When the desired length of anchor cable has been veered the windlass friction brake is set up and two chain stoppers put on anchor cable after which the wildcat is disconnected.

For letting go in an emergency, unshackle the anchor cable abaft the chain stopper, and securely lash the inboard end of anchor cable to prevent the possibility of it taking charge and returning to chain locker. Let go by tripping chain stopper.

For Towing Ship. Rig towing bridle, wire rope lashing and secure towing hawser as shown in Plate **158**.


TOWING ARRANGEMENT
Towed Ships Hawser 150 Fms. 1-5/8" dia. Steel Wire Rope
20 to 45 Fms. Anchor Chain
Towing Ships Hawser 150 Fms. 1-5/8" dia. Steel Wire Rope
BOW OF TOWED SHIP
Bow Chock
Lead of Anchor Chain when Vessel is Being Towed
Chain Stoppers
Chain and Anchor for Use in Emergency
Kenter Shackle Unshackle for Emergency Release.
5 Fathom Chain Holding Anchor

TOWING GEAR—HEAVY CRUISER.

For letting go in an emergency—trip pelican hook shown in Plate **158**.

Standard Towing Equipment for Destroyers, U.S. Navy.

The Claxton (1215-tons) type destroyers are equipped with standard towing gear as follows: Two towing bridles (one long, one short 1⅝-inch diameter wire rope) a three fathom (1½-inch diameter) chain pendant, pelican hook, shackles, and an eight-inch manila rope towing hawser.

For Towed Ship. Shackle both towing bridles together as one and with this bridle take one complete turn around the forward gun foundation. Secure the pelican hook and chain pendant to bridle. Fake towing hawser on deck clear for running and lead inboard end through bow (towing) chock from outboard and shackle to chain towing pendant.

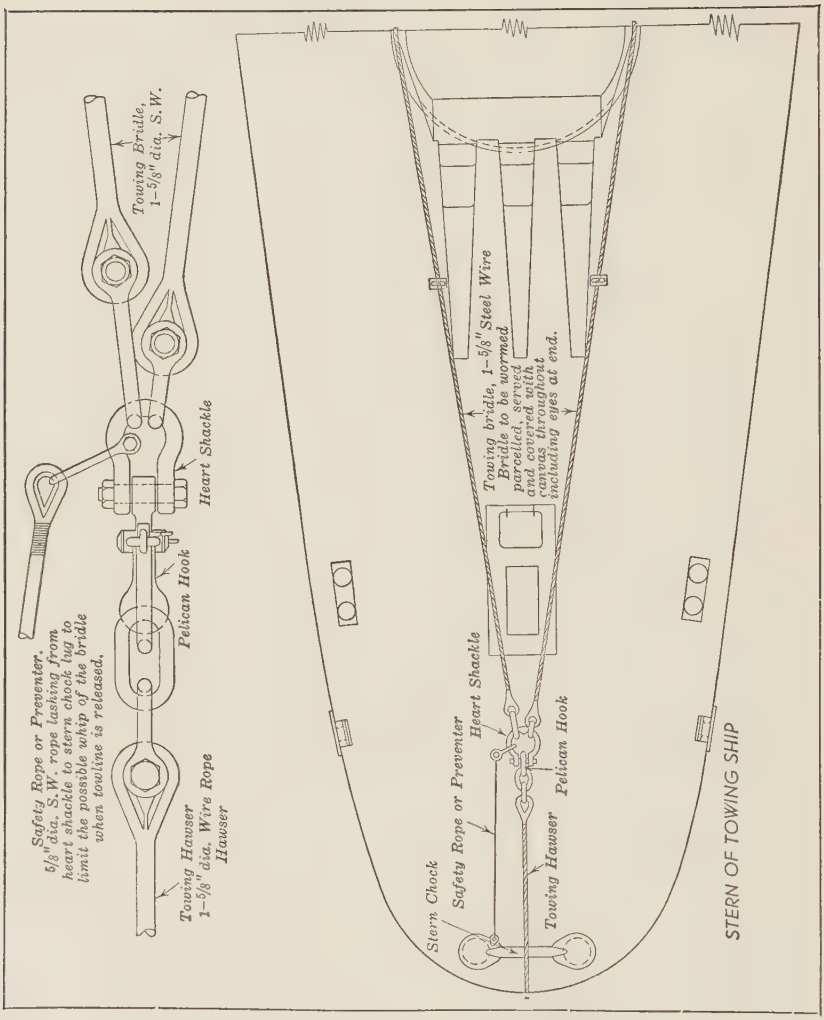
For Towing Ship. Take the one long towing bridle around the after gun foundation and make ready in all respects to shackle the towing hawser to same.

A channel bar ring is shrunk around the forward and after gun foundations for the towing bridle.

The Somers (1850-tons) type destroyers are fitted with special towing pad eyes, one forward and one aft, to which a housing chain stopper is shackled. The pelican hook of the housing chain stopper is passed through the end link of a special (three fathom 1⅛-inch diameter) chain towing pendant. The towing hawser (120 fathoms ten-inch manila) is shackled to the special chain towing pendant. Towing arrangements are shown in Plate **159**.

In passing tow lines it must be remembered that the destroyer drifts more rapidly than other vessels and lines may be passed by proceeding to windward on a heading parallel to that of the vessel to be taken in tow and drifting so as to pass just clear. If weather conditions permit, the destroyer may be backed up into wind and sea until the first line is run. It is of course advisable not to attempt to back after the tow line has been passed. When a heavy sea is running, the heading of the destroyer cannot be chosen and it is best to heave to windward. The ship will fall off into the trough and should be allowed to drift so that her stern will pass within heaving line distance

Plate No. 158


Towing Bridle, 1–5/8" dia. S.W.
Heart Shackle
Pelican Hook
Towing Hawser 1–5/8" dia. Wire Rope Hawser
Safety Rope or Preventer. 5/8" dia. S.W. rope lashing from heart shackle to stern chock lug to limit the possible whip of the bridle when towline is released.
Towing bridle, 1–5/8" Steel Wire Bridle to be wormed parcelled, served and covered with canvas throughout including eyes at end.
Heart Shackle
Safety Rope or Preventer
Pelican Hook
Towing Hawser
Stern Chock
STERN OF TOWING SHIP

TOWING GEAR—HEAVY CRUISER.

but clear of the disabled vessel. It is not difficult to accomplish this, by assisting with the engines.

Battleship and Tug Passing and Receiving Target Rafts.

Tug Passing Tow to Battleship. Both the battleship and the tug with tow head into the wind. Battleship steams at two to three knots and the tug with tow approach at three to four knots. The tug approaches the battleship on the quarter previously designated by dispatch.

Tug should have the tow streamed to the second length of tow wire. To the end of this second length of tow wire aboard the tug, secure the leading length of tow wire. To this secure a passing wire (40 to 120 fathoms long) which in turn is secured to a five-inch manila messenger of at least sixty fathoms in length.

Pass the messenger to the battleship by the use of a line-throwing gun. While the messenger, passing wire and the leading length of tow wire are being passed to the battleship, the tug tows by a pelican hook. When the battleship is ready to receive the tow, the tug trips the pelican hook. The battleship retains the messenger and passing wire aboard until time to return to tug.

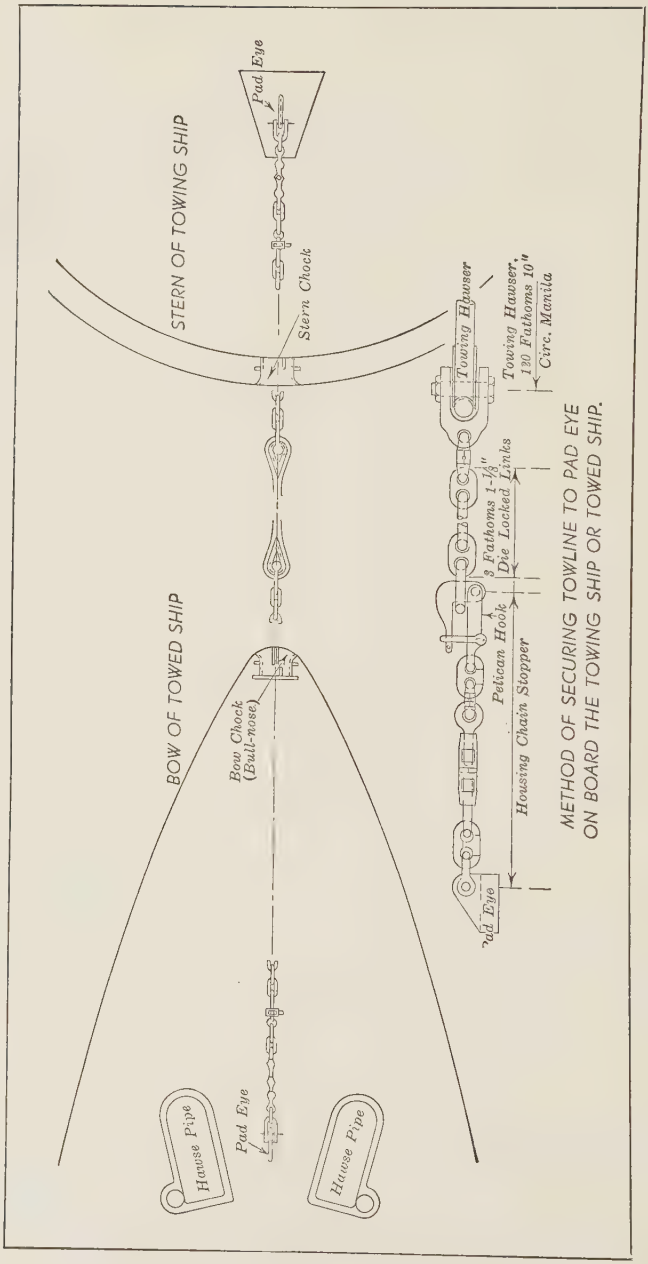
Battleship Returning Tow to Tug. In preparation for returning the tow the battleship has the end of the tow wire secured by a pelican hook over a shackle, with the strain of tow on the pelican hook. With the passing wire and the five-inch manila messenger secured to the tow wire, pass first the messenger, then the passing wire to the tug. The tug secures the passing wire, and when all is ready to receive the tow, informs the battleship, the pelican hook is tripped and the tug proceeds with the tow.

Special Notes and Information.

(a) Battleship should keep propellers, on passing or receiving side, stopped while tug is close aboard.

(b) The time taken to pass or receive the tow should be reduced to a minimum as both vessels are restricted in maneuvering until one or the other has complete control of the tow.

(c) Minesweepers and tugs can tow one target raft at 7 knots,



TOWING GEAR—DESTROYER.

two target rafts at 6 knots, three target rafts at 4.5 knots, and four target rafts at 3.5 knots.

(d) With the great sail area on a multiple tow any moderate wind against the side of the tow will cause it to drift during the passing or receiving procedure and result in difficulties of passing the tow.

(e) All target rafts at San Pedro are rigged by target repair party (under direction of Commander Base Force in accordance with Orders for Gunnery Exercises plus such modifications as approved by Commander Battle Force or Commander Scouting Force). Tugs have inadequate boats and personnel to make repairs to targets at sea. *It therefore, becomes urgent that firing forces arrange to furnish boats, personnel and tools for emergency repairs at sea.* The tugs will, however, carry material for emergency repairs to targets at sea.

(f) Where a tow line of more than 1500 yards from towing vessel to first raft is required, it will be necessary to put the additional wires aboard the battleship prior to departure for the practice. This is necessary because of the limitation of the tug's facilities for handling more than 1500 yards of towing wires on reels and on deck.

CHAPTER XVII.

MAN OVERBOARD.

The most immediate danger to a man falling overboard from a steamer is that of being struck by the propeller. This danger is especially great in the case of a vessel with twin-screws, and is of course increased in any case by throwing the stern to the side on which the man has gone over.

If the experiment is tried of throwing over from the bow a light buoyant object, it will be found that by the time this reaches the stern it will be clear of the side by a considerable distance, being thrown off by the surface wash from that side. A man falling overboard may feel this wash to a certain extent, but he sinks in the beginning far below its influence and into the suction of the screw. Moreover, his first instinct is to swim back toward the ship.

The first thought of a man falling overboard should be to swim outward from the ship, and the first thought of the officer on the bridge should be to stop, *not back*, the engines. If it is known from which side the man has fallen, the rudder may be put hard over to the same side, throwing the stern away from him. This calls for quick thinking and prompt action; but the time available is by no means as short as might be supposed. A steamer 400 feet long, making 12 knots, passes over her own length in twenty seconds. Thus, if a man falls overboard amidships, he will be ten seconds in reaching the screw.

One or more life-buoys should be thrown over at once. If a little presence of mind is exercised here, it is often possible to throw one of these very close to the man.

At the first alarm, a number of men (previously instructed), go aloft to try to keep the man in sight; and as quickly as possible a quartermaster follows them with a good pair of binoculars.

The ordinary life-buoy is so small that often the man in the water cannot see it, and it is of little or no assistance to the look-outs who are trying to keep him in sight. This is a serious

and often fatal defect. It is well to keep a number of these small light buoys about the decks, to be thrown overboard on the instant by any one who may be near them; but in addition to these, there should be provided a more elaborate buoy or float fitted with a mast and a light, to be let go promptly and to serve not only as a buoy, but as a *marker*.

If to this is added a can stuffed with oakum soaked in oil, a *slick* will be created around the buoy which will not only be of great help to the man but may assist greatly in keeping the spot in sight.

The light should be of a nature to ignite upon contact with the water. What is known as the "Holmes Light" is of this nature. In the absence of a buoy fitted as above described (or in addition thereto), lights of this kind should be carried on the bridge (or forecastle), to be thrown over by the lookout, without an order, at the alarm of "Man overboard!"

This use of a marker, as distinct from the idea of a buoy (though preferably connected with the buoy), is of great importance.

Objection is sometimes made to the use of lights like the "Holmes" on the ground that the fumes given off by them are always offensive and in some cases unbearably suffocating. This is a reason for not connecting them rigidly with the buoy. They may, however, be attached to it by a short line which would let them float at some distance from it. Of course, a light which ignites by contact with water must be sealed until it is wanted, when it may be punched or torn open either by a simple tool attached to it, as in the case of the "Holmes," or by some automatic arrangement connected with its release, as in the case of the U. S. Navy life-buoy.

Men-of-war usually carry life-buoys of special types, fulfilling more or less satisfactorily the above requirements. One of these is usually suspended on each quarter.

Under ordinary circumstances the engines are thrown to full speed astern as soon as the man is clear of the screw, and a boat is lowered as soon as the speed has been reduced sufficiently. The boat pulls back in search of the man, guided by signals from the lookouts aloft, provided they have succeeded in keeping the man or the buoy in sight. Failing this, the boat cannot go far wrong if it pulls back on a course *opposite the original heading*

of the ship; for, although the steamer in backing will probably throw her head to one side, she will not usually gain a great amount of ground in that direction before coming to rest.

In most conditions of the sea, a boat may be lowered with reasonable safety at a speed of five knots; and we may assume that the distance required to reduce the speed to this will be from two to four ship's lengths, and the time, from two to four minutes.

If the weather is smooth or the sea from such a direction that there is no occasion for maneuvering to lower the boat, all this is simple enough; but if conditions are such as to call for *turning* wholly or partially before lowering, it is thought by many officers a good plan to put the rudder hard over, keeping the engines turning ahead, and to describe a circle, thus coming back, with the ship, to a point near that at which the man went over.

Observations upon the turning circles of a large number of steamers show that a steamer turning with hard-over rudder will pass within a short distance—rarely so much as a ship's length—from the point where the rudder was put over. No doubt the symmetry of the curve may be considerably modified by wind and sea, but not sufficiently to prevent a return to the area of the starting point. The time required for the full turn will vary with the length, the speed, the weather and the maneuvering powers of the vessel. Every officer should know the maneuvering powers of his own vessel, especially the size of the turning circle, the time required to describe it, and how close the ship will come to a marker thrown over just before putting over the rudder.

Without attempting to lay down rules for the endless variety of situations which may arise in a matter of this kind, it will perhaps not be going too far to say that, generally speaking, the ship should be stopped and backed if she has the wind and sea ahead, or abeam, and that she would probably do well to turn, if they are much abaft the beam; since in the last case a boat pulling back would be working against the wind and sea.

It will, of course, be understood that, in turning, speed must be regulated according to the conditions of the weather. It would not do, for example, to come up into a heavy sea at full speed.

If the conditions are such—due to the lack of a proper marker,

or to fog, or to any other cause—that difficulty is to be anticipated in finding the man, it is probably better to stop and send the boat back along the course opposite the original heading. This emphasizes the importance of having a compass in the boat.

In case of fog, the vessel should avoid changing her position while the boat is away. The compass is thus a guide for finding the way back—assisted, of course, by sounding the whistle, firing guns, etc.

There can be no question that in weather too heavy to admit of lowering a boat, the one method that can give a hope of saving the man is to turn and attempt to pick him up with the ship.

The current "The Bluejackets' Manual" contains detailed instructions as regards equipment, condition, handling, lowering, etc., of U. S. Navy life boats.

Motor whale boats and sometimes motor launches are kept ready at sea for instant hoisting out and use as life boats.

In Squadron. Special rules are laid down for cases of man overboard in squadron. It may be assumed that all officers concerned are familiar with these. Generally speaking, they provide for the necessary maneuvers to keep clear of other ships while picking up the man and for the signals notifying other ships of the situation.

They also direct what steps shall be taken by accompanying ships to assist in the rescue. Except when the ships are in column, the actual maneuvers on the part of the vessel losing the man are not greatly different from what they would be if she were acting singly, although in certain formations there might be difficulties connected with turning.

CHAPTER XVIII.

RESCUING THE CREW OF A WRECK.

There are no hard and fast rules which can be laid down for rescuing the crew of a wreck, only what is considered the best practice by experienced and capable seamen may be stated. So many elements control the application of the general rules, such as sea, wind, urgency of immediate assistance, maneuverability of the assisting ship and the training and experience of the boat crews, that each case must be decided according to circumstances.

After having made contact and established communications, find out how urgent the case is and how much help may be expected from the crew of the wreck. If it is at night and weather conditions indicate an improvement or at least no worse weather and the master of the disabled vessel feels he can hold on and you feel you can maintain contact, *Wait for Daylight.*

Under any circumstances when the rescue begins determine the comparative drift of the two vessels and whether or not there is any wreckage about the disabled vessel, and if there is how it will hamper your boat work. If your ship drifts faster than the disabled vessel you should go to windward but if the opposite is the case go to leeward. Both vessels should distribute oil freely. If for any reason the wreck cannot use oil the rescuing vessel should steam around her, running oil freely and so create a slick into which the wreck will presently drift.

Before the rescue work begins, the boat should be equipped with two sharp hatchets in brackets, one at the bow and one at the stern; one ring life preserver with stout heaving lines made fast, two spare life jackets stopped with sail twine under each thwart, two spare oars, two small oil bags and a small tin of storm oil.

If the weather is very rough, extreme precautions will be called for in lowering the boat and getting her clear. The ship should be held with the sea on the bow, giving a lee for the boat and reducing rolling as much as possible. The crew is lowered

in the boat with life belts on. The usual sea painter is used but can be improved by splicing into the sea painter sufficient line to reach the stern sheets. The line has overhand knots in it so that when the sea painter is let go the crew can haul on it and assist the coxswain in sheering the boat clear of the ship's side. Frapping lines are used around the falls to steady the boat and sails or mattresses hung over the side as fenders to prevent the boat from being stove in if she swings in heavily.

The ship should have a boarding net, or if none is available a cargo net. The net is preferably made of ¾-inch or 1-inch stuff with about 6-inch meshes. It should be long enough to reach between the davits and deep enough to reach the water line on the weather roll of the ship. It is well to have lower part stopped to an iron pipe or bar. This affords an easy method of getting men out of the boat, and if she gets stove in all may find their way aboard. In addition it is easy to assist a disabled man on board with a man on each side to help.

Assuming that the boat gets off and makes the trip to the wreck in safety, the officer in charge must decide how he will establish communication and take off the passengers and crew. It is out of the question to go alongside to windward; and if he goes alongside to leeward, not only is there a risk of being stove by the wreckage which is likely to be found floating under the quarter, but there is the much more serious danger of being unable to get clear of the side again. As has been explained in the Chapter on Towing, a vessel lying in a seaway with engines stopped drifts to leeward at a rate which is always considerable and may amount to several knots. A boat alongside such a ship, to leeward, is in exactly the same position as if she were alongside a dock against the face of which a strong current is setting. Everyone knows how helpless a boat is under these conditions so far as getting clear is concerned. As a rule, then, the boat must never be brought actually alongside the wreck. She may either lie off to windward, keeping well clear and being held up head to sea by the oars, or to leeward, holding on with a line from her bow to the wreck, with a few oars at work backing, to keep her at a safe distance, and at right angles to the keel line of the wreck. If obliged to go alongside, the stem may be allowed to touch, all being ready to back off if the boat shows a disposition to get broadside-on. It may be well to let

the men at the oars face forward to make sure of being able to keep off. The people on board the wreck put on the life-belts, jump overboard one at a time, and are hauled into the boat. In most cases the most favorable point for working will be under the lee quarter or the lee bow, depending upon the way the wreck is lying with reference to the sea. It is sometimes possible for people to lower themselves or be lowered to a boat from the head-booms or from an overhanging main-boom, when they could not be rescued in any other way.

So serious is the question of avoiding actual contact with the wreck, that many officers consider it best for the rescuing ship to go to windward and drop the boat down with a line, putting only two or three men in the boat. This is the plan recommended by Captains Todd and Whall in their "Seamanship," and it is endorsed by a number of experienced officers who have favored the present author with their views; but a large majority of the officers who have written on this subject take the ground that a boat is always safer and more manageable with a full crew, and that to drop her down with a line from the ship simply hampers the maneuvering of both the ship and the boat without any sufficient compensating advantages. If proposing to drop the boat down with a line, it is important to make sure of having this of sufficient length. One end should be passed through the bow ring-bolt and hitched around a midship thwart. It is well to have fifteen or twenty fathoms of spare line in the boat for use when close to the wreck, as this gives the people in the boat control of the situation at the time when too much or too little may be of vital consequence. There should be certain men of the crew especially stationed to tend the line, signal the ship, throw the heaving line to the wreck, etc., for there will be no moment during the rescue when either the steering oar or the line should be left unattended. A life-belt or buoy should be taken, in this case as in the one previously described, with two lines for hauling it back and forth between the boat and the wreck.

Oil-bags are hung from the quarters of the boat and oil used by the wreck, as in all cases of this kind. If the wreck cannot assist in this way, the rescuing vessel should pass along to leeward (at a good distance) running oil freely. The wreck will soon drift into the slick thus created.

The boat is dropped down by paying out line on board, being

kept head to sea by the steering oar assisted by the drag of the line over the bow. The line must be kept in hand on board the ship, to insure a prompt response to signals from the boat. The officer in charge of the work keeps his glasses on the boat incessantly.

If the line is led through a midship chock on the ship and the ship allowed to fall off on a heading parallel with the wreck, she will drift with the latter, though perhaps not at an equal speed, and will change the distance very slowly if at all. She will, moreover, be perfectly free to handle the engines slowly—going ahead or backing as may be necessary to keep in position for giving the boat a lee. If the attempt is made to hold her up to the sea, it will be necessary to keep turning the engine ahead, which will result in drawing away from the wreck. There will, moreover, be constant danger of fouling the screw with the line, and no lee will be created for the boat.

A simple code of signals must be adopted and fully understood, thus:

In the Boat.

Right arm extended,	Slack away on board,
Left arm extended,	Haul in on board,
Arm held up overhead,	Hold on.

The arm waved, in either of these positions, emphasizes the order. Thus, the right arm extended and waved up and down means "slack away roundly."

On Board Ship.

A long blast of the whistle,	"We are about to haul in."

When the boat is near the wreck, say within thirty or forty yards, signal is made to hold on to the line on board, and the men in the boat begin to pay out, dropping down as close as is thought perfectly safe, then floating the life-belt across. This is picked up by those on board and worked as has already been described. When the boat is loaded, the signal is given and it is hauled back to the ship. Here the greatest care must be exercised and the line hauled in very slowly, else the boat is certain to be swamped.

The method of dropping the boat down by a line from the rescuing ship has been described at some length because there are

undoubtedly occasions on which it can be used with better prospects of success than other methods. In cases, however, where a boat can be used independently and untrammeled by a line from the ship—as in the cases hereafter described—it is believed that the freedom of action thus afforded the boat gives this method a very marked advantage.

The following extract from a letter received by the author gives a detailed description of several rescues by the writer of the letter, who is one of the most experienced officers of the International Navigation Company.[1] It will be noted that he believes in holding his ship as close as possible on the weather quarter of the wreck instead of going to leeward to pick up the boat; believing that more is gained by the lee afforded in this way than would be gained by the other plan.

In December, 1899, I was in charge of the boat from the *S. S. Pennland* that rescued the crew of the British Brigantine *Don Juan*, of Salcombe, England, in the North Atlantic. In the morning we discovered a vessel dismasted and rolling in the trough of the sea, the wind N.W., force about 7, and a very high sea. Getting closer to her, we saw that there were people on board of her. I got a volunteer crew and made the boat ready for lowering, taking in a couple of heaving lines, two buckets, and a large can of oil. The *Pennland* was brought to windward of the wreck close to and with the wind and sea about 4 points on the starboard bow, heading about west. The boat was lowered with the full crew, 8 men, in it and a bridle around the falls from the main deck to prevent the boat from swinging too much when lowered; a line from the fore part of the ship in the boat. The boat was lowered very quickly, and on touching the water the patent hooks disengaged themselves, the bow-line was passed aft and a strong pull on it brought the boat's bow around and sheered it clear of the ship's side. We got the oars out immediately and pulled before the wind and sea toward the wreck, having good shelter of our own vessel. When we got close to the wreck we found it impossible to get alongside, as she was rolling heavily, the sea washing over her, and part of her rigging floating alongside. We got close under her stern with the boat and had a line thrown us from the wreck; to this we bent on our heaving line and a life-belt, which was hauled to the wreck, one end being in the boat. The life-belt was put on the first man to go and the bight of the line secured around him under his arms; he jumped overboard and was pulled in the boat. The life-belt was hauled back to the wreck, and by this means all the crew, 9 in number, were rescued. Our vessel was drifting in the trough of the sea with the wreck, close to; so a short pull brought us safely alongside.

[1] Captain H. Doxrud, Steamship *Noordland*.

During the rescue the boat's crew was placed as follows: two men in the bow to work the line, four men at the oars to keep the boat in position, one man bailing and myself steering (using a long oar instead of a rudder) and directing the work.

My second experience was in October, 1892, off the Flemish Cap—when Chief Officer of the *S. S. Noordland*, when I was in charge of the boat's crew that rescued the crew of the Norwegian Barque *King Oscar the 2nd.* The wind was N.W., force about 6, with heavy hail squalls. This rescue was very difficult and dangerous, as it was done during a very dark night, and took from 9 in the evening until 1 in the morning. The *Noordland* was brought to, to windward of the wreck, heading about west, when the boat was lowered in the same manner as on the former occasion, with 8 men in it. We got safely away from the ship's side. Coming up to the wreck, we found her waterlogged, the sea making a clean sweep over her, making it impossible to get alongside. The crew, numbering 16, was taken off by means of a life-belt and line, as on the former occasion.

The *Noordland* was drifting in the trough of the sea to windward, and we pulled up to her under the lee and got safely alongside and on board with our boat load of men. The boat's crew during the rescue was placed as on the former occasion.

My third experience was in October, 1899, when in command of *S. S. Rhynland.* When off George's Bank we fell in with the disabled and waterlogged British brigantine *Ida Maud.* The night previous it had been blowing a gale from the S.E.; and at the time (about 3 P. M.), it was blowing from the N.W., force about 6, making a very nasty cross sea.

I brought the *Rhynland* to windward of the wreck, close to, heading about W.S.W., and lowered one of the port life-boats with a volunteer crew of 8 men, Chief Officer Daddow in charge. The boat got away from the ship all right and proceeded toward the wreck.

As on the former occasions, it was not possible to get alongside the wreck, the sea washing over her, and a lot of loose lumber floating about. A rope was thrown over the end of the main boom that extended several feet abaft the stern of the brigantine, the shipwrecked crew climbed out one by one to the end of the boom and dropped into the boat. In the meantime I had brought the *Rhynland* close to the wreck, her bow nearly in line with the stern of the wreck, thereby giving the boat shelter, and a short pull brought them alongside.

In these instances oil had been frequently used both from the rescuing vessel, the boats, and in the first instance from the wreck also, and I cannot recommend its use too strongly for work like this. Its effect is simply wonderful, and I attribute my success in the above cases without mishap greatly to a liberal and judicious use of oil.

The following note was furnished by Captain Randolph Ridgely, Jr., and Lieutenant-Commander W. J. Keester, both of the U. S. Coast Guard:

In Behring Sea in the days when pelagic sealing was in vogue, it was

necessary to do a great deal of boarding and it is usually rough in those waters.

The sealing schooners were about the same length and tonnage of the average "Gloucester Fisherman" (Grand Banks), and strange as it may seem, they were boarded to windward, especially when the boarding officer could make them haul aft their weather jib sheet. This made them make a dead drift to leeward and form a fine slick to windward and the boarding boat rode nicely and easily. Otherwise the boat could not have gotten away very handily. If the boat had attempted to board on the lee side, there would have been trouble.

Below are accounts of two rescues by Captain George Fried, the first when in command of the *S. S. President Roosevelt* and the second while commanding the *S. S. America.*

Steamship *President Roosevelt* (passenger), master, Capt. George Fried. Voyage 41, eastbound, sailed from New York on January 20, 1926, and at 5.40 A.M. of the 24th received an SOS from the British steamship *Antinoe.* The *President Roosevelt* arrived alongside the *Antinoe* at noon, same date, wind west, force 10, violent snow squalls, high rough sea, and began pumping oil overboard with excellent effect, the master of the *Antinoe* claiming that this saved his vessel from sinking.

At 9 P.M. during heavy snow squalls the *President Roosevelt* lost sight of the *Antinoe,* whose radio and dynamo were out of commission, but picked it up again at 3.40 P.M. of the 25th with her engine and fireroom flooded and No. 3 hatch broken. The vessel had also a heavy list to starboard.

The weather moderated, and an attempt was made by the *President Roosevelt* to send a manned life boat. While lowering the boat, a vicious hail squall hit the vessels, making the sea too rough for life boats, and spilling out the crew, who managed to get back into the boat covered with fuel oil and apparently exhausted. The life boat crew were ordered aboard the *President Roosevelt* with the exception of two men, who were lost overboard. Every effort was made to rescue these men, but due to darkness and hail squalls this was impossible.

On the 26th as the *Antinoe's* distress signals indicated a perilous situation, the *President Roosevelt* attempted to float a boat to her by aid of Lyle gun; this did not prove successful and they tried to float a cask, which also failed.

On the 27th another attempt to float a boat to the *Antinoe* with end of line leading from top of after king post, failed, and was lost. The Lyle gun was fired fifteen times but carried away near projectile frequently. Colonel Hearn, artillery expert, a passenger, suggested using a spiral spring between projectile and line, which was successful. Chief Engineer Turner had made thirteen projectiles.

At 7.20 P.M. on the 27th the *Roosevelt* was successful in rescuing twelve men from the *Antinoe* in a life boat, which was so badly damaged that it was cut adrift after the crew was safely aboard.

At midnight, the remainder of the crew of the *Antinoe* was rescued. The master had to be carried aboard and his crew were in a pitiable condition, due to exposure, lack of food and water for two days and little clothing.

On January 28 the *President Roosevelt* proceeded on her voyage, leaving the *Antinoe* still floating with both decks awash and 50° starboard list. Having stood by the *Antinoe* for three and one-half days, the crew of the *President Roosevelt* were almost exhausted from long vigil.

ACCOUNT OF THE RESCUE OF THE CREW OF THE *S. S. FLORIDA* BY THE *S. S. AMERICA* ON WEDNESDAY, JANUARY 23RD, 1929. AS RECITED BY CAPTAIN FRIED, MASTER OF THE *S. S. AMERICA*. From files of the Disability & Vessel Personnel Division, Operations Department, U. S. Shipping Board, June 27th, 1929.

On our homeward bound voyage experienced succession of westerly and northwesterly gales with very high rough seas accompanied by heavy snow and hail squalls. January 22nd received SOS from American Steamship *Dunnedaike* and Italian Steamship *Florida*, both vessels giving their positions in latitude 38 north and longitude 60 west. Ascertained then that several vessels were in their vicinity but only one had a radio compass, and distressed vessels could not be located so decided to proceed to their assistance about noon January 22nd.

We were then three hundred fifty miles north of their reported position. We were covered with ice in freezing weather and having violent snow and hail squalls with heavy gales. Chief Radio Operator Nelson Smith was stationed at the radio compass direction finder and took bearings continuously. We proceeded on these courses, the bearings of the *Florida* were erratic, that is they appeared so, because they were not checking or agreeing with his reported position. Kept searching and taking bearings but these bearings all placed him north, which we believe to be in error due to his given position from 9 A.M. until noon of Wednesday.

Weather cleared and moderated, observations were taken and our position found. Asked the *Florida* to obtain a position but she informed us they had no navigation book as all equipment was destroyed when their bridge was carried away. However, the master had a sextant and he took an observation and gave us his altitude. We worked them out and plotted him in latitude 40.30 north, longitude 57.30 west, which was one hundred and fifty miles northeast of his given position.

We immediately turned about and proceeded to take radio bearings which checked with our findings. We proceeded full speed on our new course, her radio signal getting stronger all the time as darkness came on. Our searchlight was lighted so he could see us, and at 6.30 P.M. we sighted the *Florida* dead ahead. This proved the accuracy and efficiency of the radio compass, without which the *Florida* could not have been located. Took a position on the *Florida* weather beam, quarter mile distant with weather overcast. Light snow squalls and threatening. Chief Officer

Harry Manning with eight members of crew including Junior Engineer W. J. Clark, Bos'nmate, A. Wilson; Chief Storekeeper, S. Bracco; sailmaker, J. Taltes; M.A.A., V. Waleck; Q.M., W. Trettin; A.B., F. Kellam; A.B., J. Harrobin, were lowered in No. 1 life boat and proceeded to *Florida.* Getting alongside the *Florida* was very difficult owing to her heavy list and her leerail being under water sending out a tremendous surge. Getting nearer, Officer Manning found all hands ready to abandon ship. He maneuvered life boat close as permissible to *Florida.* He threw a line on board, keeping about fifty feet distant, and instructed *Florida's* crew one at a time pulling themselves through the water by this line to the boat, where they were dragged on board by the boat crew. The bow oarsman spoke Italian and translated all instructions and orders. Things went along in this fashion until the line carried away due to a heavy surge. A man half way over had to be hauled back on board the *Florida.* The life boat was again maneuvered successfully and a line placed aboard and thus succeeded in getting the entire crew off and into our boat.

The Captain was the last to leave and informed Officer Manning that there was none left behind and no pets on board. The boat, then loaded with forty-one men, nine members of boat crew and thirty-two rescued, turned about and headed for the *America,* which was then in a position to leeward of the *Florida.* The weather by this time had reached gale force with violent snow and rain squalls with a high sea running. The boat proceeded running to leeward, the oarsmen being assisted by the able members of the rescued. Meanwhile the *America* maneuvered into position and the boat reached the ship's starboard side. Ship's side was strung with ladders, monkey rope and cargo nets and our highly prized two home-made breeches buoys, which proved invaluable in getting the injured men on board. Not a single man of the crew was able to climb up the ship's side unassisted. They were in a pitiable condition, half of them being near naked and the other half with very little clothing.

They were dazed and hysterical from their long exposure. The rescued were all hoisted and lifted safely on board and rushed below for medical attention. The boat's crew came up and the boat cut adrift owing to high sea running. It was impossible to hoist the life boat without prospects of severe injury to members of the crew. Chief Officer Manning had to be pulled up and on board by Mr. King, the First Assistant Engineer. Six of the *Florida's* crew were severely injured and four were very ill. One man was lost overboard Sunday at 10 P.M. All secured and proceeded towards New York leaving *Florida* in a sinking condition without lights. Do not think she could outlive the night in this gale. We now found out why it was so difficult to locate her due to her heavy list and the loss of her rudder. Her Captain believed she would capsize if he did not keep his engine turning over slowly. He was steaming at about three knots changing his position constantly.

Captain Manning and every member of the *America* life boat crew are to be congratulated upon their heroic task in making this rescue under very difficult and extreme conditions. It was a splendid piece of work.

If the weather is such that a boat cannot be lowered, the difficulties of effecting a rescue are greatly increased, but the situation is not necessarily hopeless. There are many ways of getting a line between the ships; as, for example, by a line-throwing gun, a rocket, or a float. If a balsa is available, the following method might give some hope: The rescuing vessel steams slowly across the stern of the wreck, towing the balsa by a very long line, and maneuvers in such a way as to cause the line (not the balsa) to foul the wreck. If the people on board can haul the balsa up to leeward and get on it there should be no great difficulty about saving them.

Another method which suggests itself is the following: Suppose it is apparent that the wreck is drifting faster than the rescuing vessel will drift if she stops her engines. The rescuing vessel goes to leeward and places herself, with engines stopped, in such a position that her bow is just clear of the line of drift of the stern of the wreck. If any miscalculation is made, a few turns of the screw astern will carry her clear. As the wreck drifts down, a line is gotten across by any means that is convenient and the people are hauled across. If the rescuing vessel drifts the faster she will of course go to windward instead of to leeward, and wait to drift into position herself. In this way it should be possible without imprudence to let the vessels come much closer than would be safe in any other maneuver that could be attempted.

An unusual case of the rescue of the entire crew of a foundering vessel in heavy weather without the lowering of a boat is that of the saving of the crew of the *U. S. S. James*, a mine sweeper, by the gunboat *U. S. S. Marietta*, Commander H. G. Hamlet, USCG, commanding, in the Bay of Biscay on April 28, 1919. In a gale of wind, with very heavy sea, the *James*, with fires out and waterlogged, was sinking. Weather and sea conditions made it impossible to attempt a rescue by boat; action of some sort was imperative if the imperiled lives were to be saved. The *James* was lying with wind and sea on her port quarter. The *Marietta* was placed for a while in the *James'* wake, and heading with her, in order to determine the comparative drift. As was to be expected, it was found that the *Marietta* drifted the faster. The *Marietta* was then placed with her bow lapping the lee quarter of the *James*, heading with her, and only a few feet distant,

and a heaving line was passed on board. The *Marietta* was held in position, with the helm and engines, at a distance that at no time during the operation of rescue exceeded fifty yards. A 4-inch line was hauled on board the *James* and the bight was secured to a Carley life raft in such fashion that the raft could be hauled back and forth from one ship to the other. In this manner the entire crew of the *James,* forty-seven in all, were transferred to the *Marietta,* nine trips being made. The crew of the *Marietta* were stationed along the rail on the forecastle head with bowlines, and, as the raft came near the *Marietta's* bow, a bowline was passed to each man on the raft and he was hauled on board. During the operation oil was used freely by throwing it overboard from the port side of the *Marietta*; on the *James* the heads of oil barrels on the after deck were broken in. Shortly after the *Marietta* had rescued the crew and backed clear the *James* sank.

A life raft, with sunken deck, is much better adapted to an operation of the sort described than is a decked life raft. Had a decked raft been used in this case the men would have been in danger of being swept off by the seas.

It is possible that were the wreck a vessel with high decks and the sea too rough for boat work a breeches buoy might be used. If the rescue vessel could get a heavy hawser to the disabled vessel and have it made fast in the waist, she could keep a good strain on it by steaming slowly to leeward, keeping in the lee of the wreck. A breeches buoy could then be rigged. There would be little or no jump to the breeches buoy hawser and by carefully tending the whip that sets up on the hawser it should be practically overcome. It is well to remark here that the towing hawser should be made fast on the disabled vessel so as not to slew her and spoil your lee, *i.e.*, somewhere in the waist.

In smooth weather where it is impracticable to approach the wreck by boat because of fire, the rescue may be made by the rescuing vessel without the use of boats or rafts. This has been accomplished in at least two cases by vessels of the Navy and Coast Guard. In 1916, the Coast Guard Cutter *Yamacraw* extinguished fire aboard of the *S. S. Antilla* and in 1918 the Destroyer *Bainbridge* rescued the personnel of a French transport in the Sea of Marmora.

In 1916 the Coast Guard Cutter *Yamacraw,* under the com-

mand of Ensign Farley, put to sea from Norfolk to answer the distress calls of the *Antilla,* afire about forty miles off Cape Charles. He found the *Antilla* with a cargo of sugar and mahogany, a raging furnace. The *Yamacraw* went to windward of the *Antilla* and placed her bow against the *Antilla's* hull. Lines were run from each quarter of the *Yamacraw* and made fast to the hull of the *Antilla.* The *Yamacraw* then steamed slowly ahead while tending the quarter lines to keep her bow against the *Antilla's hull.* By this method it was possible to keep six lines of fire hose playing on the fire. The ship was finally towed into Lynnhaven Roads and salvaged. In the case of the *Bainbridge,* the transport was loaded with explosives, and no attempt was made to put out the fire, but only to rescue all personnel. Here the *Bainbridge* placed her bow against the transport, and all hands scrambled to safety across her bow. As soon as all were aboard, the *Bainbridge* backed clear.

CHAPTER XIX.

STRANDING.

The first impulse of an officer upon finding his vessel stranded is usually to throw the engines to full speed astern. This may be the right thing to do, but it is not always so. If the ship has struck a rock, the chances are that she will have a hole in her bottom, and to back off may result in sinking her without leaving time even for saving life. If aground on a soft bottom, to work the engines either way may result in disabling them by filling the condensers with sand or mud. Again, where a single-screw steamer is aground forward, backing the screw may slew her stern around and put her on the beach throughout her full length. These are points which should be taken into consideration in deciding whether or not to back the engines immediately.

Assuming that, for whatever reason, it proves that the vessel cannot be backed off at once, the most urgent step to be taken is to lay out an anchor and get a good strain on a line from this, for holding the ship from being set farther up on the beach. Such a line, kept well taut, will sometimes start a ship off quite unexpectedly by the steady pull which it exerts; a slight rise of the tide or a little working of the ship by the wind or sea contributing toward the same end. As the laying out of a large anchor involves delay when every moment may be precious, it is well to send out a kedge at once, following this as soon as possible with a stream or a bower. If there is a current setting along the coast, as frequently happens, the anchor should be laid out a little off the quarter, to keep the stern from being swept around. A buoy with a good buoy-rope should be used on the anchor. While this work is in progress, careful soundings should be made around the ship on all sides, and a good leadsman stationed to note the rise or fall of the tide. The Tide-Tables, Sailing Directions, and Charts will of course be examined, the time of high water determined, and the direction of tidal currents noted. If there is a chance that help will be needed, no time should be lost

in communicating with shore and making such arrangements as the situation calls for. The immediate assistance of a vessel large enough to carry out a heavy anchor may be of the greatest value. It may be possible to secure a fishing vessel for this. If a tug can be secured, this may be the best use that can be made of her in the beginning.

An examination of the ship should be made as soon as possible after she strikes, and all compartments sounded. As already noted, this is particularly important on a rocky coast. If a compartment is found to be holed, the water-tight doors leading to it should be closed, the bulkheads braced, and the pumps put on, to keep the water down. If the hole is a large one, there will probably be danger in hauling off before stopping it at least in part. Repairs of this nature (before hauling off) can only be made from the inside.

When measures have been taken to prevent the ship from being set farther up the beach, *and not until then,* the work of lightening her may be begun—ballast tanks pumped out, cargo shifted, lightered, or thrown overboard. If the ship is aground forward, something may often be gained by filling the after ballast tank or otherwise adding weight aft; as, for example, by shifting coal from an extreme forward to an extreme after bunker.

Getting out the boats is a quick and simple way of lightening the ship. They may be filled at once with provisions and other stores of such a nature as to be handled quickly, these being taken first of all from the forward holds—assuming the ship to be aground forward. If the beach is near, this freight may be landed and the boats brought alongside to be loaded again.

A man-of-war, with a large crew and plenty of boats, should be able under these circumstances to get rid of several hundred tons of easily handled stores within an hour or two. At the same time, the work of shifting weights from forward to aft can be going on, those articles being chosen first which lend themselves to "man-handling," such as boxes of provisions, bales of clothing, ammunition (except very heavy projectiles), cordage, etc. Much is gained if the conditions admit of letting go the anchors immediately and paying out the cables. This alone, if quickly done, might suffice to float a ship which was only lightly aground well forward. But this will be dangerous if there is any chance

of the ship being driven farther up so that she may strike on the anchors. It is a good rule in any case of letting go an old-fashioned anchor when aground, to unstock it and foul the flukes with several turns of cable.

All water in tanks forward should be pumped overboard. Nor should it be forgotten that one thousand men assembled aft gives a weight of approximately one hundred and fifty thousand pounds to help lift the bow.

When conditions become favorable for backing and hauling off—which will of course be at high water—the chances of success will be greatly increased if the ship can be moved in her bed, either by rocking her from side to side or by slewing her stern a little. This may perhaps be done by means of a line to an anchor laid out on the beam or quarter.

Vessels have been worked loose from a sandy bottom by *going ahead* with their engines; the suction current drawing aft along the bilge acting apparently to scour out the sand.

When a heavy sea is running and it is evident that some time must elapse before a successful effort can be made to float the stranded vessel, use should be made of the vessel's pumps, if in good condition. Whether on a sandy or rocky beach it might be well, under these conditions, to have the vessel fill her double bottoms and any empty tanks with salt water. This may prevent her from working farther up the beach or from smashing in her bottom. When all is ready for pulling, in an attempt to release her, the vessel begins to pump out the salt water, timing it with the rising tide and the power being exerted in the attempt to float her.

If another vessel comes to the assistance of the stranded vessel she immediately makes preparations for running hawsers, laying out anchors, etc. In the meantime, the assisting vessel should get all the information possible from the master of the stranded vessel. If the master of the assisting vessel has not gained a personal knowledge of the local conditions by experience he should supplement his knowledge by questioning the local people. Unless it is a very isolated locality there will be many people watching the operations. Information as to the nature of the bottom, peculiarities of currents and wind may be obtained from Coast Guardsmen if there be a nearby station. If there are no Coast Guardsmen, there will probably be local fishermen and sea-

faring people who will probably volunteer no information but will glady give it, if tactfully approached. If the first man approached feels there is someone else better acquainted, he will probably bring him on board.

It is generally assumed that a vessel will come off easiest the way she went ashore. This is not always the case and the reason why not will probably be obtained from those of special knowledge of the locality.

The assisting vessel should, as a rule, anchor to seaward, with a good scope of chain, get good lines from the stern of the stranded vessel, and heave these taut until she tails in toward that vessel or as nearly so as the wind and tide permit. If she then starts her anchor windlass ahead and keeps full steam pressure on it, she will not only keep the lines taut, but will take in and hold every inch that is gained on the line between the ships. When the time comes for a combined effort to haul off, she starts her engines ahead, still keeping the anchor windlass in action.

It is a good plan for the assisting vessel to lay out her own spare anchors well off shore with good lines bent to them, and to send the ends of these lines on board the stranded vessel. These will be heavier than the anchors that the stranded vessel could conveniently lay out for herself, and can be placed to far better advantage. This does not interfere with any of the other methods of assisting that have been described.

If weather is bad and a heavy sea is running the most difficult part of the job will be to get a heavy hawser on board the stranded vessel. If she is a deep draft vessel and has not worked too far up on the beach she most likely will be outside of the heavy breakers and the hawser may be run by boat, having care of the backwash. With the improved shoulder gun or line-throwing apparatus there should be little risk or trouble in getting a running line aboard the stranded vessel and if she has steam on her windlasses she can heave the heaviest hawser on board. If she is so far up the beach that it is impossible to fire a line to her from the assisting vessel, she may be reached by a shoulder gun in a boat, the boat taking the running line in and then bending the shot line to it, after the shot line is aboard the stranded vessel.

If the assisting vessel does not have expert and experienced boat crews, advantage may be taken of local boats. The local

men are usually expert surfmen and they will put the running line aboard.

It may be assumed as certain that if a stranded vessel is on an open beach, it is impossible to float a line to her.

In cases where a strong current runs along the beach at certain stages of the tide, if the lines are hove taut at slack water, the current when it makes will be on the beam of the anchored vessel and will exert a tremendous force, with all the advantage due to the span formed by the anchor-cable and the towline. It would be well here for the assisting vessel to have two anchors down.

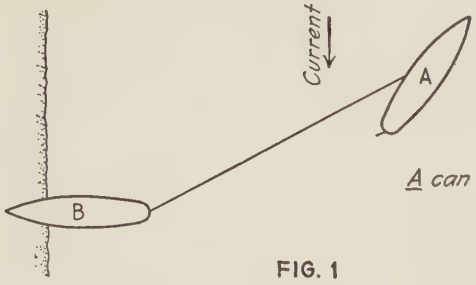
And it is imperative that she should be prepared to cast off or cut the line between the ships without an instant's delay, in case she finds that her anchors are dragging and that she is being set down toward the beach. Here, as in the case described below, where the assisting vessel cannot anchor, it is desirable to lead the hauling line from a chock far enough forward of the stern to admit of using the rudder for holding the head up more or less toward the tide. She will thus be pointed toward safety if she begins to drag, and by starting the engines ahead with hard-over rudder, the situation is changed into one resembling that of Fig. 1, Plate **160**.

In all cases like the above, of attempts to pull a stranded vessel off, there is danger that if she comes off suddenly she will collide with the vessel that is assisting her. The latter should therefore be ready to slip everything and get out of the way.

There is one possible advantage which results from having the towing ship under way. This is that if she does not start the other vessel by pulling directly astern, she can place herself on the quarter and may thus be enabled to slew the stern of the stranded vessel and so loosen her up in her bed.

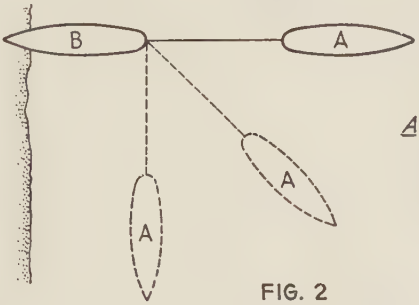
Generally speaking, however, the difficulties are increased if the assisting vessel cannot anchor. It is almost impossible for her to keep a steady tension on the line, under the most favorable circumstances; and if the wind or the current is across, there is great danger that she will swing around on the towline and end by going ashore herself.

The only thing to be done where the assisting vessel cannot anchor is for her to lie off, head to the current, until all is ready; then to run the line, *taking it from one of her own chocks fairly well forward*—not under any circumstances from the stern. She



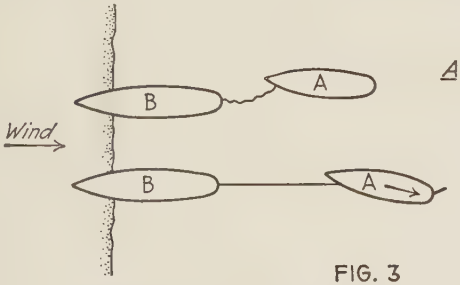
A can manoeuver freely.

FIG. 1



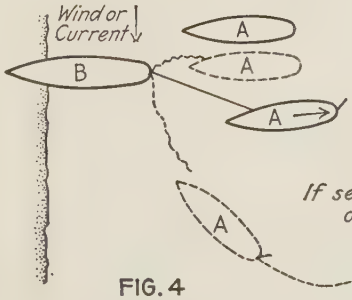
A is unable to manoeuver because line leads from stern. May be swept down onto beach.

FIG. 2



A stands in close and takes line, then backs full speed.

FIG. 3



A takes position to windward and drifts down, takes line and backs full speed.

If set down toward beach, A casts off and backs clear.

FIG. 4

ASSISTING A STRANDED VESSEL.

then heads more or less across the current and goes ahead, putting the strain on the line gradually and holding herself up against the tide by the helm, which will have good turning power because of the way the ship can pivot on the line (Plate **160**, Fig. 1). With the line led through a stern chock, the rudder would have no power, and the ship would be swept down helplessly toward the beach unless she cut the line (Plate **160**, Fig. 2). Even when maneuvering as above described, an axe should be at hand to cut if necessary.

It may happen that the assisting vessel can approach *bows-on* to the stranded vessel and receive a line forward, taking it in through her own bow chock, and backing her engines to pull off. This may save much time which would be lost in maneuvering for position to take the line in aft and may make all the difference between being "just in time" and "just too late." Here again the importance must be emphasized of retaining the power to pivot on the line, by bringing it in through a chock some distance abaft the stem. (Plate **160**, Fig. 3.) This method is especially applicable if the wind is off shore. If the wind or current is setting down along the beach, the line must, in this case, as in that of Fig. 1, be run from the windward (or tideward) side.

In Fig. 4, Plate **160**, the assisting vessel stands in as close as is considered prudent, and a little to windward, and drifts down past the stern of the stranded vessel, to receive the line. If she is obliged to cut and get clear to save herself, she is helped by the tendency to throw her stern up into the wind which is a characteristic of all backing vessels.

If the draft of the assisting vessel permits her to go alongside she should be placed with her stern to the beach. If her bower anchors are laid out and her anchor engine kept running, this may be a powerful help. It may happen, too, that the current from her screw, going ahead with full power, will scour out the bottom under the stranded vessel.

There are, of course, many cases in which the effort to back off should be made immediately; as, for example, when it is known that the beach on which the ship has struck is hard and steep and not rocky. Here she will certainly be aground forward only, but there is great danger that she will swing around and ground throughout her whole length. And if this does not happen, the chances are that if there is any sea on she will be

dangerously strained and perhaps broken in two. So here the one chance may be to back at full speed immediately—not, however, neglecting other measures which do not interfere with it. If it is found that the backing is slewing her around broadside-on, the engines must be stopped. This is very likely to happen with a single screw. On a beach of this kind, it is particularly important to get an anchor laid out immediately. A light kedge carried out at once on the quarter opposite that toward which she is inclined to swing around, may be of vital importance.

If all other methods fail, resort must be had to regular salvage operations, the description of which is beyond the scope of this book.

The following plan is recommended by an officer of long experience, as especially valuable in cases where a vessel is stranded on a muddy or sandy bottom (not rocky) and where another vessel goes to her assistance:

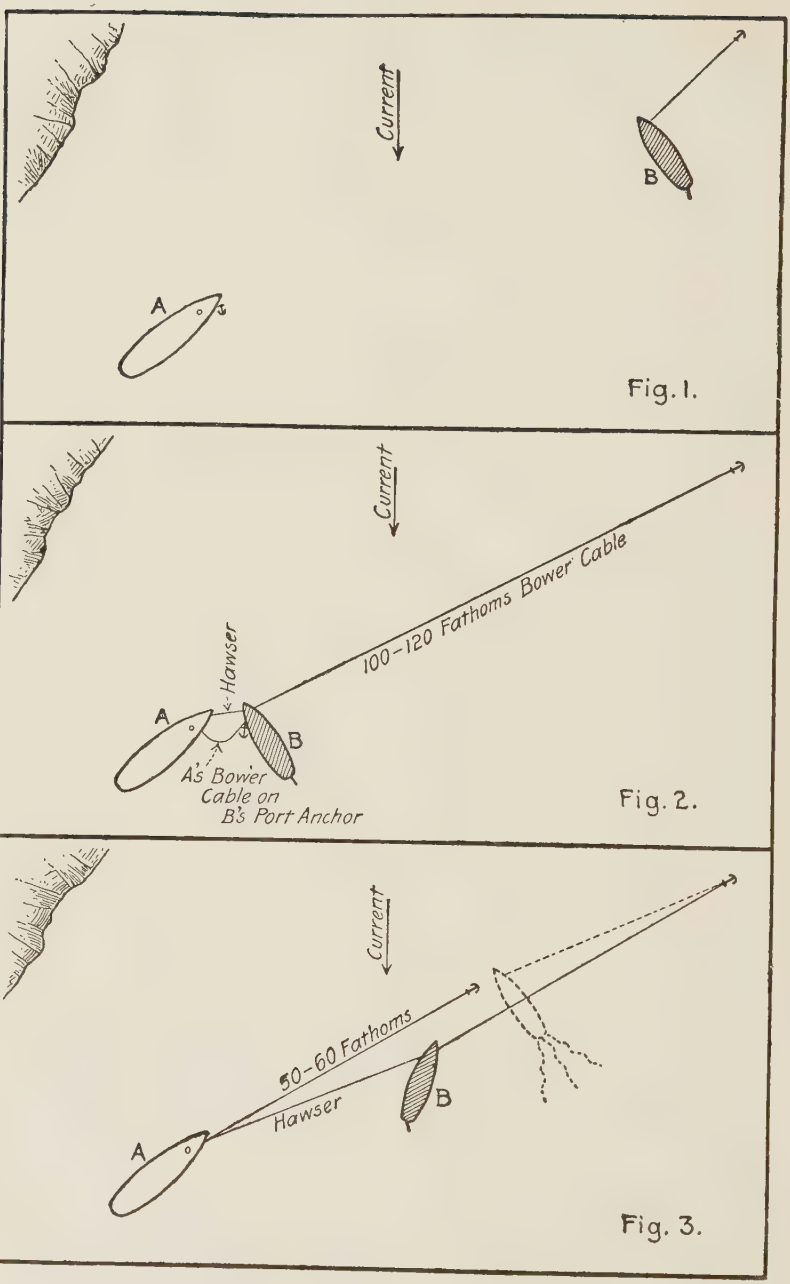
Referring to Plate **161**, *A* is aground, and *B* goes to her assistance. *A* being on the left side, facing the current, *B* drops her starboard bower anchor at a distance from *A* not exceeding her available scope of cable, and goes ahead with left rudder, keeping the current on the starboard bow and allowing herself to be set over toward *A* until she is as close as is practicable, which will of course depend primarily upon her draft. *A*'s starboard bower anchor is now transferred to *B*'s port bow, if this can conveniently be done, by boats or otherwise; or, more simply, *A*'s starboard bower cable is unbent and the end is hauled across and shackled up to *B*'s port bower chain, disconnected at a convenient shackle.

At the same time a good hawser is run between the ships. If this hawser is run immediately, it will help to hold *B* in position while getting the chain across and may save some troublesome maneuvering in quarters perhaps uncomfortably close. Fig. 2.

Everything being ready, *B* starts her steam-windlass and heaves in her starboard cable, using her screw as before, but this time with the current on the port bow and more nearly ahead than before.

A, in the meantime, veers away her starboard cable, which is thus laid out by *B*. Fig. 3.

When *A*'s cable is all out, or when no more of it can be laid out, *B* lets go the anchor and *A* heaves in on her cable, and makes



HAULING OFF A STRANDED VESSEL.

fast the hawser connecting with *B*. At the same time, *B* heaves in on her steam windlass, and goes ahead with her screw. Thus we have the windlasses of both ships pulling on *A*, with the power of *B*'s screw added, and, still further, the effect of the current acting on *B*'s port bow, and, provided *A*'s bow yields enough to cant her, acting on *A* as well.

If the current cannot be brought on the port bow of *B* by rudder or anchor from *B*'s starboard bow, a spring from *B*'s port quarter may be bent to the hawser and taken to the winch. If successful, care must be taken not to foul the propeller with the spring.

It frequently happens that, when a vessel grounds on a sandy beach, the sand will make up and "pack" around the hull. The presence of "packed" sand may be determined by the use of the lead line around the hull. If packed sand is found and the stranded vessel has steam on her boilers, the master should rig jets over the side, while awaiting for the next favorable tide. The steam jets should be alternated with pipes connected to the fire mains. About an hour before beginning to pull, the pumps and jets should be started. This will result in making the sand "live sand" and will release its grip on the vessel's bottom, bilges and sides.

The practice of "jumping on a line" when the stranded vessel is a large one is generally futile, unless she is hung up at one spot which is easy to determine as she will swing. On small craft, this may be done as a last resort just around high water.

If it is decided to try "jumping on a line" (a sudden pull with full power), great care must be taken not to get the line in the propeller, as the hawser must be paid out over the stern and made fast to the towing bitts, since there are probably no other bitts or part of the ship that will stand the strain. Assume that the assisting vessel has been pulling on the stranded vessel and that the hawser is made fast to both ships, and further that fifteen or twenty fathoms of the hawser have been kept aboard the assisting ship for paying out. The assisting vessel starts slowing her engines a few revolutions at a time. As the hawser slacks, bend the end of a whip to it, close to the stern rail, and heave it on board. Have another whip ready to bend on as soon as you get some of the hawser aboard and fleet the whips. As it comes aboard the hawser is faked

down ready for running, standing part inboard, running part outboard. The amount of hawser so faked down depends entirely on the judgment of the commanding officer, the strain his hawser will stand and the strength of the bitts and their fastenings. When all is ready the engine room is ordered to have a full head of steam. As soon as the officer aft reports the hawser clear of the propeller, have all hands aft get well clear and ring ahead full speed.

No one can predict what is going to happen or what will carry away. The suspense is short; she either comes off, something carries away, or you settle down to a pull under full speed, which you then know is useless until more favorable conditions exist.

As a last resort, a small vessel, if lying broadside to the beach where it is possible to pull on her beam or almost so, may be floated by heaving her down. This method was successfully used by Captain (now Commodore) C. S. Ridgely, U. S. C. G., in floating a three-hundred-ton schooner, after all other means had failed.

A bridle is made fast just below the lower mastheads, the towing hawser is made fast to this bridle. Preventer shrouds and stays are rigged to take as much of the strain off the masts as possible. The additional precaution is taken of battening down all hatches and openings where water might get below.

About an hour before high water an easy strain is taken on the hawser. The vessel will then take a slight list and as the tide rises and increasing strain is taken on the hawser the list increases. There is now an excellent chance of floating the stranded vessel at about high water. Of course there is the risk of carrying away the masts, but if the vessel is in an exposed position and the weather gets worse, the chances are she will be a total loss.

The following notes have general application in working on stranded vessels:

1. Secure the running line about six to eight fathoms from the end of the hawser with a rolling hitch and then at frequent intervals stop the running line to the hawser with sail twine or small stuff that may easily be cut adrift. About two fathoms from the end of the hawser take a marline or clove hitch with the running

line around the hawser and again stop the running line to the hawser with small stuff beyond this hitch. This prevents jamming when being taken on board and gives plenty of drift to make fast before casting off the running line.

2. No precautions are too great to prevent the hawser getting into the propeller. An officer should be stationed where he can direct and have supervision of paying out and handling the hawser while it is being run.

3. Never turn over the engines until the officer in charge aft reports all lines clear of the propellers.

4. Have a petty officer, preferably a carpenter's mate, stationed with a sharp axe where he can cut the hawser promptly.

5. Except in an extreme emergency, never start or stop the engines suddenly with a hawser made fast to another vessel.

6. To avoid a vessel charging into the assisting vessel, have a thorough understanding with the master of the stranded vessel as to just what to do if she comes off with a rush.

7. When all is ready to pull, orders should be given to the engine room by phone or speaking tubes:

"Ahead slow" (Previously understood to be the least number of revolutions possible to get way on ship).

As the strain is taken on the hawser give the order to increase speed 3 R.P.M., and so on until the maximum number of revolutions are being made or until the vessel is floated.

8. If the vessel comes off or if it is found that she cannot be floated on the tide you are working on, decrease speed by slowing down a few revolutions at a time until the stop order is given. Thus you will have full control of the situation and avoid any danger of getting the hawser in your propellers.

9. When assisting a vessel stranded on a lee shore, proceed as above in getting a strain on the hawser. Both vessels heave in on their anchor chains at the same time. If you have anchored with a greater scope of chain than she has, she will break out her anchors first, and should immediately get one ready for letting go. By the time you break yours out you will have taken the necessary strain to tow her off shore and probably to a safe anchorage. If anything goes wrong she can let go her anchors and probably be in no worse position than before.

CHAPTER XX.

WEATHER.

I. Introduction.

The following chapter on weather presents an outline of the modern concept of the physical processes that make up weather. Most people, seamen in particular, are interested in weather as it affects them or their work. They want to know how hard the wind will blow and when, and will there be fog, clouds, rain or snow, or clear fine weather. This chapter will not answer any such queries directly. But a careful study of this chapter combined with intelligent observation of daily weather will form a starting point to a knowledge of weather. In addition the chapter contains a simplified resume of the methods of preparing weather maps, analysis of weather, and forecasting.

Older treatments of weather were mainly descriptive. Older methods of weather forecasting were by "rule of thumb" or empirical. They are still useful. Some empirical rules continue to be used by weather forecasters who are well versed in modern methods of forecasting. Descriptive treatment of weather, such as that which may be found in Bowditch, should be read in addition to the material of this chapter.

Other sources of descriptive weather information are the United States Coast Pilot and the Sailing Directions for various localities. In these will be found descriptions of the general weather of the locality and descriptions of special or unusual weather that might be encountered.

While in Norway, Dr. Sverre Petterssen, who is now teaching at M. I. T., developed the methods which are presented in this chapter. Acknowledgment is due him for granting permission to adopt the material.

In the Pacific Coast Pilot, for example, may be found a description of a "Santa Ana" or desert wind which is peculiar to the coast of southern California and is dangerous to shipping. In the sailing directions for the West Coast of Mexico may be found a description of an unusually strong northerly wind which occurs in the Gulf of Tehuantepec. Seamen frequenting these localities should of course be prepared for local weather by a study of Coast Pilots or Sailing Directions.

To understand weather it is necessary to understand the physical processes involved which produce the weather. These physical processes are outlined in a simplified form and, as far as practicable, in a descriptive manner. If, from the chapter following, the only facts retained are the weather features of cold air masses and warm air masses, a distinct start will have been made in understanding the weather. Much further progress will follow when the significance of various cloud forms is understood. When the foregoing has been accomplished the basis for a practical knowledge of weather will have been reached.

II. The Atmosphere.

Atmosphere is the name given to the air which surrounds the earth and which is carried along with the earth. The atmosphere extends to great heights, 100 miles or more, but it is only the lower part that concerns the weather. The highest clouds (cirrus) are seldom higher than 33,000 feet above sea level. One half of the total weight of the atmosphere is contained in the 16,000 feet just above the earth's surface.

Although air is very light it has a definite weight. At ordinary pressure and temperature 1 cubic foot of air weighs 1.22 ounces. Due to this weight the atmosphere exerts pressure on the earth's surface; this pressure, on the average, amounts to about 15 lbs. per square inch. A column of water 33 feet high, or a column of mercury 30 inches high will each exert an equal pressure, 15 lbs. per square inch. Either a water column or a mercury

column can be used to measure atmospheric pressure. The mercurial barometer is used because of the more practical and convenient length of the mercury column and because mercury has a low freezing point ($-38°$ F.).

Atmospheric pressure decreases with height above the surface of the earth. The difference in pressure between two points one above the other, is equal to the weight of the air column between the two points.

III. Composition of the Atmosphere.

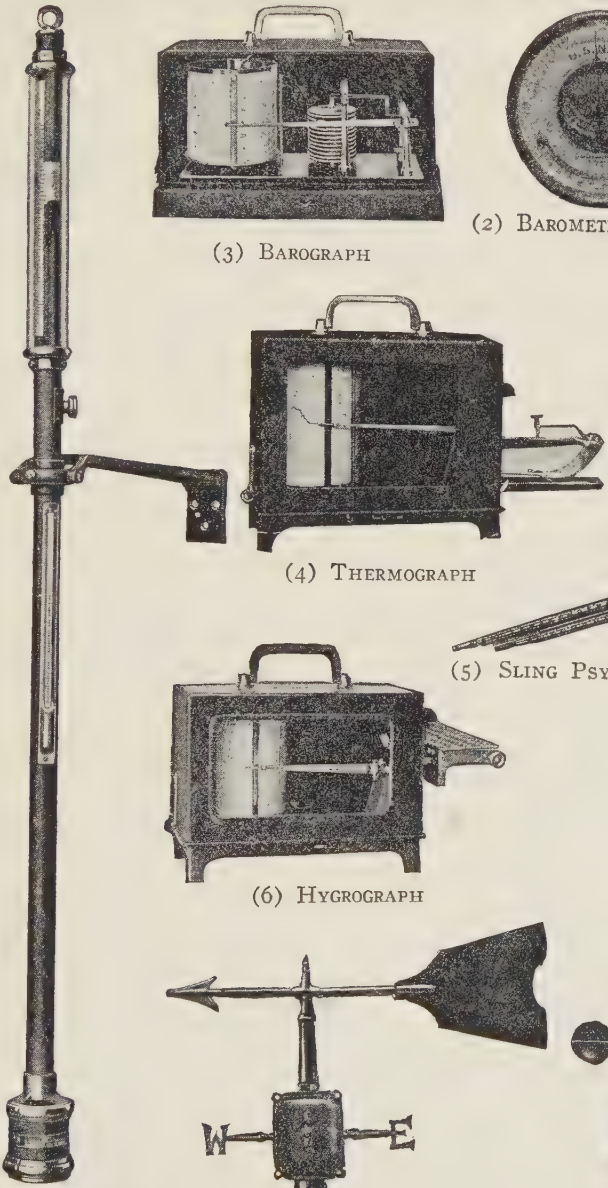
Air is a mixture of gases. Pure, *dry* air contains about 78% nitrogen, 21% oxygen, and almost 1% argon. In addition, there are traces of other gases but these are of no practical importance in weather study.

Water vapor was not included in the gases making up dry air, for in fact it would not be present in completely dry air. The air of the lower atmosphere is never completely dry, however, because water vapor always is present. It is present in varying amounts, and in many respects water vapor is the most important gas in the atmosphere. The maximum amount of water vapor that can be present in the atmosphere depends entirely on temperature, the higher the temperature the greater the capacity of the atmosphere to hold water vapor. Whenever the maximum capacity for a given temperature is reached, the air is said to be saturated. When saturated air is cooled, condensation will take place. Water vapor, which is an invisible gas, condenses to visible water droplets or ice crystals. Small water drops and small ice crystals are kept afloat in the air by ascending air currents and are visible as clouds. When the water drops or ice crystals become large enough they will fall as rain or snow. The formation of rain and snow will be described more fully later.

There are also present in the atmosphere at all times, various impurities such as dust and smoke particles from land, and salt particles from the sea. Individual particles usually are invisible

(3) Barograph

(2) Barometer, aneroid



(4) Thermograph

(5) Sling Psychrometer

(6) Hygrograph

(1) Barometer, mercurial

(8) Anemoscope

(7) Anemometer

AEROLOGICAL INSTRUMENTS (Surface)

(Figures 3 to 8, courtesy of Julian P. Friez & Sons. Figure 1, courtesy of Taylor Instrument Companies)

to the naked eye but collectively the particles affect visibility and the coloring of distant objects.

The impurities in the air affect not only visibility but they also provide nuclei for the condensation of water vapor. In purified air, condensation does not take place readily and a supersaturation can occur. The presence of impurities in the atmosphere, however, insures condensation taking place at saturation temperature. Some impurities, such as salt particles, are hygroscopic and are active condensation nuclei. There is always a sufficient supply of condensation nuclei present in the atmosphere.

IV. The Meteorological Elements.

To describe the weather from a land station or from a ship at sea, the following meteorological elements are observed and reported:

1. Pressure.
2. Pressure change in the three hour period preceding the observation (tendency).
3. Temperature.
4. Dew point.
5. Wind direction and force.
6. Cloud forms.
7. Cloud amounts.
8. Ceiling.
9. Visibility.
10. Weather.
11. Type of precipitation.
12. State of ground (field conditions), land stations only.
13. State of the sea, some coastal stations and ships only.
14. Sea temperature.
15. Ocean swell, ships only.

In addition to the above, specially equipped stations, both ashore and at sea, make observations and reports on upper air

conditions. Upper air reports include wind, temperature, pressure, and humidity.

Complete information for observing and reporting weather is contained in instructions issued by the U. S. Weather Bureau. For weather reports from ships, the instructions are in the pamphlet, INSTRUCTIONS TO MARINE METEOROLOGICAL OBSERVERS. This pamphlet also contains descriptions of meteorological instruments.

Atmospheric pressure is measured by a mercurial barometer or by an aneroid barometer. The mercurial barometer (Plate **162**, Fig. 1) is standard but small ships may carry only the aneroid type (Plate **162**, Fig. 2). The mercurial barometer is usually direct reading but corrections for temperature and gravity are necessary. The readings are corrected to a temperature of 32° F. The correction for gravity changes the reading of the mercurial barometer to that which would be obtained at latitude 45° N. Aneroid barometer readings are not similarly corrected. Aneroid barometers should be compared frequently with mercurial barometers corrected for temperature and gravity. Any difference in readings at the comparisons is corrected for in future readings of the aneroid barometer. In order to have a common plane to compare pressure readings obtained at different heights above sea level, all barometer readings are corrected finally to the pressure that would occur if the barometers were moved to sea level. The correction of pressure to a sea level plane is necessary even for barometers on ships, where the barometers are located a comparatively few feet above sea level.

Pressure reports are now made in special meteorological pressure units called millibars (mb). Normal sea level pressure is 1016 millibars, which corresponds to former pressure units of length, 30 inches of mercury, or 762 millimeters of mercury. Most barometers are still graduated in inches or in millimeters so that readings have to be converted to the equivalent pressure units when weather reports are sent out. A millibar is a pressure

of 1,000 dynes per sq. cm. The relation between the new pressure units and the older ones may be expressed as follows: 1,000 mb. equals 750 mm. equals 29.53 inches.

The *barograph* is a recording aneroid barometer (Plate **162**, Fig. 3). This instrument is necessary to obtain the amount and the character of the pressure change, called *barometric tendency,* which takes place in the three hours preceding the time of the weather observation.

Temperature of the air is measured with a mercurial thermometer. In order to obtain correct air temperatures air must circulate freely around the thermometer, and the instrument must be shielded from the direct radiation from the sun or from local heat sources. At land stations thermometers are mounted in a wooden, louvered instrument shelter which in turn should be located in as open a space as practicable. On shipboard the air thermometer is located in a small louvered shelter called a psychrometer case. The location of the psychrometer case seldom is satisfactory for all conditions of wind and sea so that special steps to obtain accurate air temperature are often necessary on board ships. Accurate air temperature may be obtained with a sling psychrometer, as will be explained in a succeeding paragraph describing observations for humidity, and by means of an aspiration thermometer.

An aspiration thermometer consists of a thermometer mounted in a tubular shield made of a good reflecting and insulating material. One end of the shield is open to admit air, and on the other end of the shield is a small spring driven fan which draws air in the tube and around the thermometer. An aspiration thermometer may be used at any suitable exposure on board ship, preferably to windward. The readings of the protected thermometer inside the shield are not affected by sunshine or by radiation from local heat sources such as hot stacks. The aspiration thermometer is in use in ships of many nations but is not in general use in United States ships, naval or merchant.

A recording thermometer called a *thermograph* (Plate **162**, Fig. 4), keeps a continuous record of temperature. A bi-metallic strip is the sensitive element in this instrument. It is calibrated by comparison with a mercurial thermometer.

In English speaking countries thermometers are graduated with the Fahrenheit scale (F). Elsewhere, and in scientific studies, the Centigrade scale (C) is in common use. Conversion from one scale to the other may be accomplished readily. The freezing point of water is 32° F or 0° C. The boiling point of water is 212° F or 100° C.

Water vapor content of the air is expressed usually in terms of relative humidity, specific humidity, or dew point temperature.

Relative humidity is the ratio of the actual amount of water vapor in a given volume of air to the amount which would be present were the air saturated. Relative humidity is expressed usually as a percentage.

Specific humidity is the number of grams of water vapor per kilogram of air.

Dew point temperature is the temperature at which a given mass of air will become saturated as its temperature is lowered.

Relative humidity is obtained by the use of a dry bulb and a wet bulb thermometer. A combination of dry bulb and wet bulb thermometers is called a psychrometer. When mounted on a frame and provided with a handle for whirling the combination is called a *sling psychrometer* (Plate **162**, Fig. 5). Whirling is desirable to insure the adequate ventilation necessary to obtain correct temperatures. The wet bulb thermometer consists of an ordinary mercurial thermometer with a light muslin covering over the bulb which is wet with water when used. When the air is saturated no evaporation will take place from the wet bulb and the wet bulb and dry bulb thermometers will indicate the same temperature. When the air is not saturated evaporation will occur from the wet muslin covering on the wet bulb thermometer. Evaporation cools the wet bulb, lowering the tempera-

ture it indicates. The amount the temperature is lowered depends upon the amount of water vapor present in the air and the temperature as indicated by the dry bulb thermometer. Relative humidity is obtained from humidity charts or tables, using the dry bulb and wet bulb temperatures as arguments for the charts or tables. Dew point temperature also is obtained from humidity tables and specific humidity may be calculated from relative humidity.

A *hygrograph* is an instrument which records relative humidity (Plate **162**, Fig. 6). The expansion and contraction of strands of human hair in varying humidity conditions are utilized to indicate relative humidity. Such an instrument is calibrated with a psychrometer.

Wind direction is the direction from which the wind blows, an east wind being a wind blowing from east towards west. Weather codes provide for reporting wind direction to the nearest compass point, from 01 to 32. The code 00 represents a calm, 8 is the code for east, 16 is the code for south, 24 is the code for west, and 32 is the code for north. Wind direction is estimated by eye from the known course of a ship, or other known direction. Wind vanes, also called *anemoscopes*, are also used to obtain wind direction (Plate **162**, Fig. 8).

Wind speed is obtained from an anemometer (Plate **162**, Fig. 7) and the speed is expressed in knots, miles per hour, meters per second, or in Beaufort force numbers. The latter is used in weather reports. Experienced observers are able to estimate the force of the wind when an anemometer is not available. The table on page 627 gives the Beaufort scale of wind force.

Wind is not a steady current. Wind speed varies in gusts and lulls, and its direction may change two or more points during short period variations. Surface friction setting up eddies, combined with irregularities due to convectional currents in instable air produce variable wind currents. The reported wind direction and speed is the mean direction and speed.

Beaufort Scale of Wind Force

Beaufort No.	Seaman's Description	Action of fishing smack	Effect ashore	Sea miles per hour (knots)	Land miles per hour	Weather Bureau forecast terms
0	Calm	Makes no headway	Smoke rises vertically.	0–1	0–1	
1	Light air	Just has headway	Does not move wind vanes, but wind direction shown by smoke drift.	1–3	1–3	Light.
2	Slight breeze	Wind fills sails; makes up to 2 knots	Wind felt on face; leaves rustle; ordinary vane moved by wind.	4–6	4–7	
3	Gentle breeze	Heels slightly under full canvas; makes up to 3 knots.	Leaves and small twigs in constant motion; wind extends light flag.	7–10	8–12	Gentle
4	Moderate breeze	Good working breeze; under all sail heels considerably	Raises dust and loose paper; small branches are moved.	11–16	13–18	Moderate
5	Fresh breeze	Shortens sail	Small trees in leaf begin to sway; crested wavelets form on inland waters.	17–21	19–24	Fresh.
6	Strong breeze	Double reefs mainsail	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	22–27	25–31	Strong
7	Moderate gale (high wind)	Remains in harbor, or if at sea, lies to	Whole trees in motion; inconvenience felt in walking against wind.	28–33	32–38	
8	Fresh gale	Takes shelter if possible	Breaks twigs off trees; generally impedes progress.	34–40	39–46	Gale
9	Strong gale		Slight structural damage occurs (chimney pots and slate removed).	41–47	47–54	
10	Whole gale		Seldom experienced inland; trees up rooted; considerable structural damage occurs.	48–55	55–63	Whole gale.
11	Storm		Very rarely experienced; accompanied by widespread damage.	56–65	64–75	
12	Hurricane			Above 65	Above 75	Hurricane

(1) Cirrus (Ci)

(2) Cirrocumulus (Cc)

Clouds take an endless variety of forms but for purposes of description and classification the clouds may be grouped in a small number of families and types. The international classification arranges clouds in 4 families and 10 main types. For details of cloud forms reference should be made to the United States Weather Bureau's pamphlet, CODES FOR CLOUD FORMS AND STATES OF THE SKY.

CLOUD CLASSIFICATION

1. Cirrus	(Ci)	Family A	
2. Cirrocumulus	(Cc)	High Clouds	Average lower level, 20,000 ft.
3. Cirrostratus	(Cs)		
4. Altocumulus	(Ac)	Family B	Average upper level, 20,000 ft.
5. Altostratus	(As)	Middle Clouds	Average lower level, 6,500 ft.
6. Stratocumulus	(Sc)	Family C	Average upper level, 6,500 ft.
7. Stratus	(St)	Low Clouds	Average lower level, close to
8. Nimbostratus	(Ns)		surface.
9. Cumulus	(Cu)	Family D Clouds with	Average upper level, that of cirrus.
10. Cumulonimbus	(Cb)	Vertical Development	Average lower level, 1,600 ft.

Cirrus (*Ci*) (Plate **163**) have an average altitude of 31,000 feet. Cirrus has a fibrous (thread-like) appearance and feather-like form. Cirrus take various shapes, and when arranged irregularly as detached clouds in a light blue sky are called *fair weather cirrus.* When cirrus are arranged in bands or other patterns, and also when connected with cirrostratus or altostratus, they usually are the advance clouds of a low pressure system or storm area. Near the tops of cumulonimbus, or thunderstorm clouds, a specal kind of cirrus (cirrus densus) usually is present. This cirrus type often is called *false cirrus* because it is denser and usually lower than other cirrus forms.

Cirrocumulus (*Cc*) (Plate **163**) have an average altitude of 24,000 feet. They are small rounded masses or white flakes of clouds without shadows, arranged in groups and often in lines.

Cirrocumulus develop from cirrostratus and observation of this development is a positive way of identifying this type. High altocumulus often are mistaken for cirrocumulus. Either cirrocumulus or altocumulus when covering the sky arranged somewhat in regular waves and showing blue sky in the gaps produce a "*mackerel sky,*" which sometimes precedes a storm area.

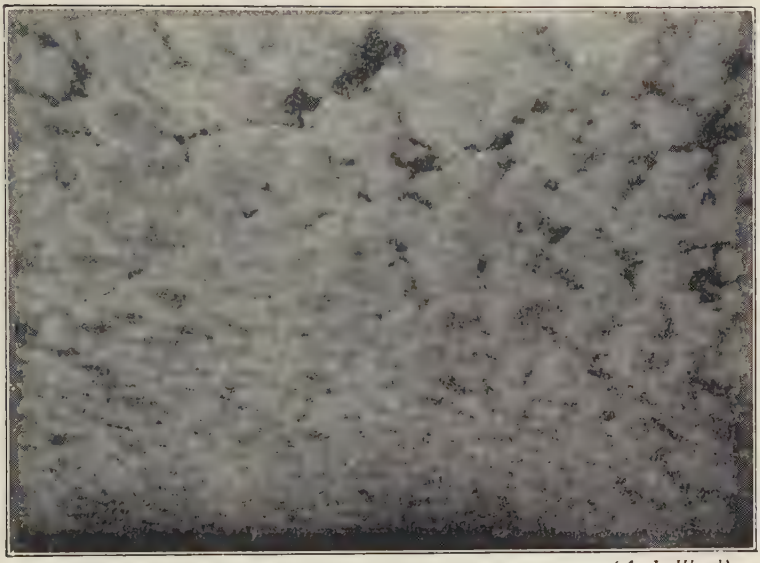
Cirrostratus (*Cs*) have an average altitude of 29,000 feet. Cirrostratus is a thin sheet of whitish cloud, sometimes covering the sky completely and giving the sky merely a milky appearance when it is called a cirrus haze, and at other times presenting a fibrous structure like a tangled web. Halos around the sun or moon are caused by cirrostratus. This cloud type is often a sign of an approaching storm area, especially when observed to grow denser and merge into altostratus.

The three cirrus types, cirrus, cirrocumulus, and cirrostratus are composed always of minute ice crystals. Other cloud types are composed of water droplets. With cirrus types the outline of the sun is visible always, and the sun will cast shadows except when both sun and clouds are low down on the horizon.

Altostratus (*As*) have an average altitude of 15,000 feet. This type is a dense sheet of a grey or bluish color, sometimes forming a compact mass of dull grey color and fibrous structure. The sun or moon may be seen dimly through the thinner forms of altostratus. Thickening of the cloud sheet obscures the sun or moon, and such thickening of altostratus usually precedes a prolonged period of steady precipitation.

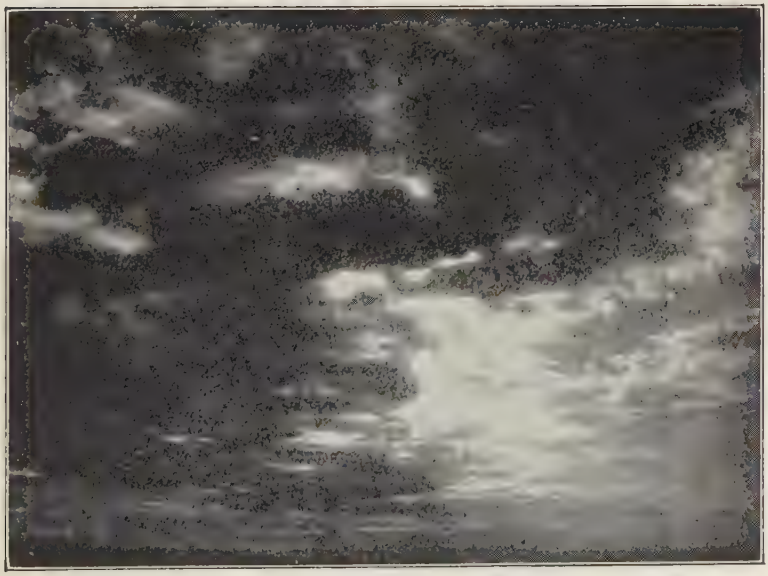
Altocumulus (*Ac*) (Plate **164**) have an average altitude of 13,000 feet. These clouds differ from cirrocumulus in consisting of larger, rounder masses, white or greyish, and are partly shaded. An important variety is known as *altocumulus castellatus.* They resemble ordinary altocumulus but they develop some turreted tops which look like miniature cumulus. Thunderstorms usually follow the appearance of altocumulus castellatus.

Stratocumulus (*Sc*) (Plate **164**) have an average altitude of



(A. J. Weed)

(1) Altocumulus (Ac)



(2) Stratocumulus (Sc)

(1) Cumulus (Cu)

7,000 feet. They are cloud layers of lumpy masses or rolls of dull grey clouds frequently covering the entire sky, especially in winter. These clouds frequently resemble altocumulus when arranged in a regular pattern.

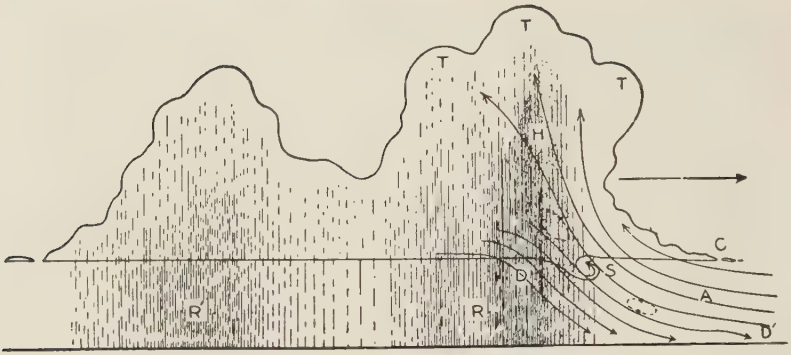
Nimbostratus (*Ns*) have an average altitude of 4,000 feet. They consist of a dense layer of dark shapeless cloud from which steady precipitation usually falls. Altostratus usually is present above the nimbostratus. Detached, ragged parts of nimbostratus drifting below are called *fractonimbus* or *scud.*

Stratus (*St*) have an average altitude of 25,000 feet. Stratus is a uniform layer of low cloud like a fog, but not in contact with the earth's surface. If broken up into ragged masses it may be called *fractostratus.*

Cumulus (*Cu*) (Plate **165**) have an average altitude of 4,000 feet for the base, while the tops tower to an average height of 10,000 feet. Cumulus is a thick cloud of which the upper surface is dome shaped and exhibits rounded protuberances while the base is usually horizontal. A flat type of cumulus without protuberances is called *cumulus humulis* or *fair weather cumulus.* Towering cumulus with protuberances, having a cauliflower appearance, especially when observed to be increasing in size are called *cumulus congestus* and may develop into cumulonimbus.

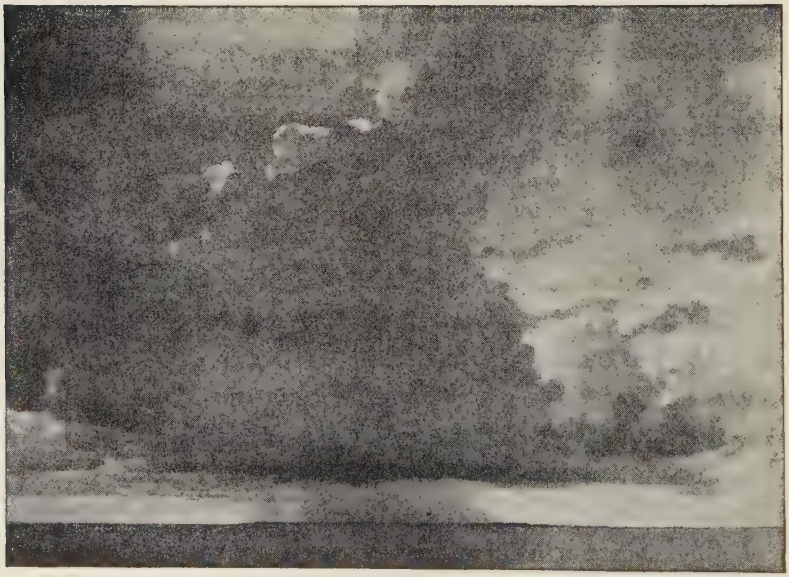
Cumulonimbus (*Cb*) (Plate **166**) have an average altitude of 5,000 feet for the base, while the tops tower to an average of 18,000 feet. This cloud is the thunder shower cloud. It consists of great masses of cloud rising in the form of mountains, towers, or anvils, while at its base there is usually a cloud mass similar to nimbostratus. Near the tops false cirrus is usually seen. From the base local showers of rain, snow, or hail usually fall, and frequently a thunderstorm develops. A *line squall* is a continuous line of cumulonimbus clouds arched across the sky, and usually advancing perpendicularly to the line of clouds.

Fog is defined as obscurity in the surface layers of the atmosphere. By international agreement, the term *fog* is limited to a



(1) Cross-section of a typical thunderstorm

Ideal cross-section of a typical thunderstorm. *A*, ascending air; *D*, descending air; *C*, storm collar; *S*, roll scud; *D'*, wind gust; *H*, hail; *T*, thunderheads; *R*, primary rain; *R'*, secondary rain. (*Humphreys.*)



(2) Cumulonimbus (Cb)
THUNDERSTORM

condition of atmospheric obscurity in which objects at a distance of 1 kilometer (1100 yards) are not visible. When visibility exceeds this limit but is less than 2 kilometers (2,000 yards approx.), the condition is termed *mist* or *haze* according to whether it is produced by condensed water particles or by solid impurities such as dust or smoke. The term *mist* sometimes is applied also to a very fine precipitation, or drizzle.

Fog may be defined for practical purposes as a cloud in contact with the earth's surface. Fog will form when air at the surface is cooled below the dew point. Fog is formed by two main processes, advection and radiation.

Advection fogs are formed by the passage of warm air over a cool surface. This is the common type of sea fog and is more prevalent at sea in spring and summer when warm continental air or tropical air flows over cool oceans. Advection fog is frequent throughout the year over cold ocean currents.

Radiation fog is principally a land phenomena, forming on clear nights in quiet air. At night the temperature of the earth's surface over land areas is lowered by radiation of heat out into space. Air in contact with the cooled surface has its temperature lowered at times to the dew point, condensation and fog resulting.

Radiation fogs usually are shallow. Advection fogs are thicker but occasionally this type may be shallow enough for mast heads of ships to protrude above the fog. The sun has a tendency to burn off fog during the day. Strong winds will dissipate radiation fogs quickly and may dissipate advection fogs. However, an advection fog can persist and even thicken in strong winds.

Precipitation includes all forms of water, solid and liquid, which fall through the atmosphere. *Hydrometeors* is another word adopted by meteorologists for this same meaning of precipitation. In recent years knowledge of the forms of precipitation has assumed increasing importance in weather forecasting.

An accurate report of precipitation forms not only indicates the kind of air mass that is present, but also indicates the thermodynamic process which is taking place to produce the precipitation.

Reference to the latest edition of "INSTRUCTIONS TO MARINE METEOROLOGICAL OBSERVERS," published by the United States Weather Bureau, will show that more than 50 kinds of precipitation may be reported. The above publication should be consulted for details about the various kinds of precipitation, in particular for definitions of rain, snow, hail, soft hail, sleet, drizzle, shower, fog, mist, and haze. A brief general classification of the main types of precipitation follows in the next three paragraphs.

1. More or less *continuous precipitation*, rain or snow, falling from an unbroken cloud cover. This is frontal precipitation caused by slow upward movement of a large air mass.

2. *Showers*, which may be of rain, snow, or hail, are characterized by sudden beginning and ending and rapid changes in intensity. This precipitation forms in cumulo type clouds in the rapid upward movement of small bodies of air when the general mass of air is more or less instable. There is usually a clearing between showers with patches of blue sky, or at least a lightening of the clouds.

3. *Mist* or *drizzle* falls from fog or stratus clouds when there is little or no upward movement of the air.

Cloud amount or *cloudiness* means the amount of the sky covered by clouds. *Taking the whole sky as unity*, the amount of cloudiness is expressed in tenths. When possible, observations are made of the amounts of high, intermediate, and low clouds.

Ceiling is the height of the cloud base above the earth's surface. The height is estimated or it is determined by small balloons ascending at a known rate, and timed until the base of the clouds is reached.

Visibility is a term used in describing the transparency of the

atmosphere, and it is defined by the maximum distance an object can be seen. As used, visibility refers to a more or less horizontal direction. Visibility in a vertical direction usually is not reported or estimated. It is not uncommon to have poor visibility looking skyward when horizontal visibility is excellent. Such a condition is caused by a haze layer which frequently exists at various heights above the earth's surface.

Horizontal visibility is useful as an indicator of the thermal structure of the lower atmosphere. Generally, visibility is good when air temperature is lower than the sea temperature. This temperature condition exists in a cold air mass as will be described later. On the other hand, when the air temperature is higher than the sea temperature a condition for the production of haze and fog is present. The latter condition exists in a warm air mass and poor visibility is the result, whether or not the extreme condition, fog, is present.

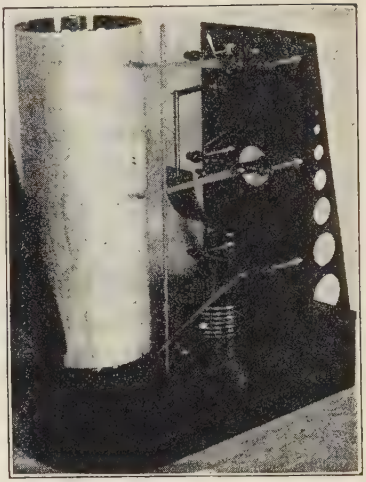
Sea temperature is obtained from the temperature of the main injection or by taking the temperature of a sample of water obtained from the sea with a bucket. The main injection temperature is satisfactory when there is assurance that a properly located, accurate thermometer is used.

The temperature of the ocean surface combined with air temperature is an important aid in understanding some types of weather and in forecasting the weather. When these data are accurately obtained the question of whether the air mass is a cold air mass or a warm air mass can be decided.

Observations of the *state of the sea* and the *character and direction of the swell* are made and sometimes reported from ships. These reports are not important for predicting weather, although swell may indicate the distant presence of a tropical cyclone or other severe storm.

Upper air conditions, including winds, temperature, pressure, and humidity at various heights, may be obtained when special equipment is available (Plate **167**). For wind speed and direc-

(1) AEROGRAPH MOUNTED ON PLANE



(2) AEROGRAPH (COVER OPEN)

(3) SHIPBOARD THEODOLITE AND PILOT BALLOON

AEROLOGICAL INSTRUMENTS (UPPER AIR)

tion the track of a pilot balloon, rising at a constant rate, is obtained by following the balloon with a theodolite. Elevation angles and the horizontal bearing of the balloon is obtained each minute. The data obtained are plotted to determine the wind speed and direction at various heights. When clouds do not interfere, a pilot balloon may be followed with a theodolite to heights of 10,000 feet or more. Pilot balloons sounding up to 20,000 feet are not uncommon when the visibility conditions are good.

Temperature, pressure, and humidity in the upper air have been obtained in recent years by carrying an *aerograph* aloft in an airplane or attached to a sounding balloon. The aerograph (Plate **167**, Fig. 2), also called a *meteorograph*, combines a recording aneroid barometer for pressure, a thermograph for temperature, and a hygrograph for humidity. Plate **167**, Fig. 1, shows an aerograph mounted on an aeroplane. A meteorograph for use with a sounding balloon is a lighter instrument than the airplane type. When the sounding balloon bursts the instrument is floated to earth by a small parachute. Some of these instruments are never recovered but a surprisingly large percentage of them have been recovered in the past.

A *radio meteorograph* has been developed and is replacing the other types of meteorograph. The radio meteorograph is carried aloft by a sounding balloon and automatically transmits temperature, pressure, and humidity as it is carried aloft.

V. Temperature Distribution in the Atmosphere and Some Related Physical Processes.

By use of sounding balloons and airplanes, carrying recording instruments, many observations of temperature in the upper air have been made. Sufficient observations have been obtained to determine the average variation of temperature with height. From the surface to a height of several miles the temperature decreases about 3° F. for every 1,000 feet, on the average. See Plate **168**.

At varying heights; around 50,000 feet above the equator, 30,000 feet at latitude 50°, and 20,000 feet over polar regions; the temperature stops falling with further increase of height and remains constant or even increases slightly. The lower atmosphere, where the temperature decreases on the average 3° F. every 1,000 feet, is called the *troposphere.* The region above the troposphere, where the temperature remains practically constant with further increase of height, is called the *stratosphere.* The boundary between the troposphere and the stratosphere is called the *tropopause* (See Plate **169**).

The troposphere is a region of ascending and descending air currents. (Ascending and descending air currents are called *convection currents* or simply *convection.*) When air ascends its pressure is lowered. Expansion and cooling of the air accompanies reduction of pressure. When air descends its pressure is increased. Compression and heating of the air accompanies increase of pressure.

Convection currents, therefore, are mainly responsible for the existing variation of temperature with height above the earth's surface. In the stratosphere, where the temperature remains constant with height, it is assumed that there are no convection currents. Here the existing temperature condition is believed to be due to a balance between incoming and outgoing radiation.

The rate of change of temperature with change of height is called *lapse rate.* The average lapse rate in the atmosphere is 3° F. per 1000 feet (0.6° C. per 100 metres).

When air ascends or descends rapidly, its temperature is lowered or raised at the rate of about 5½° F. for each thousand feet change of height. Convection of this type occurs with cumulo type clouds, especially the cumulonimbus. The change of temperature of 5½° F. for each 1000 feet change of height is called the *dry adiabatic lapse rate.*

All normal atmosphere air contains some water vapor. When the temperature of ascending air is reduced to its dew point,

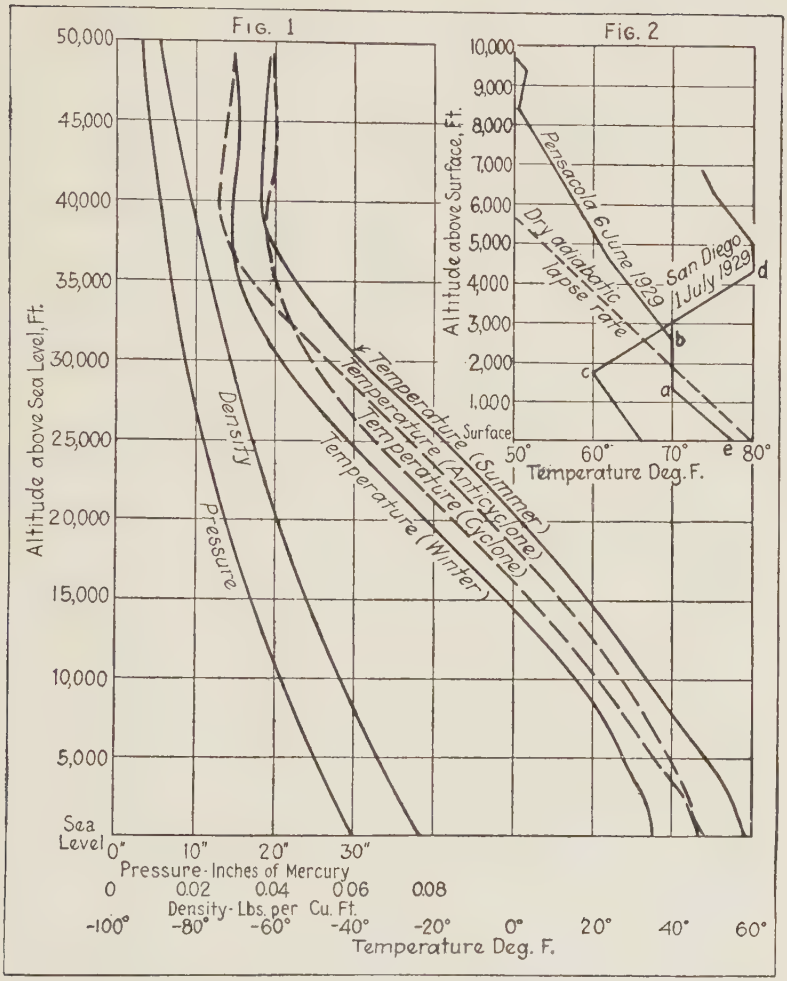
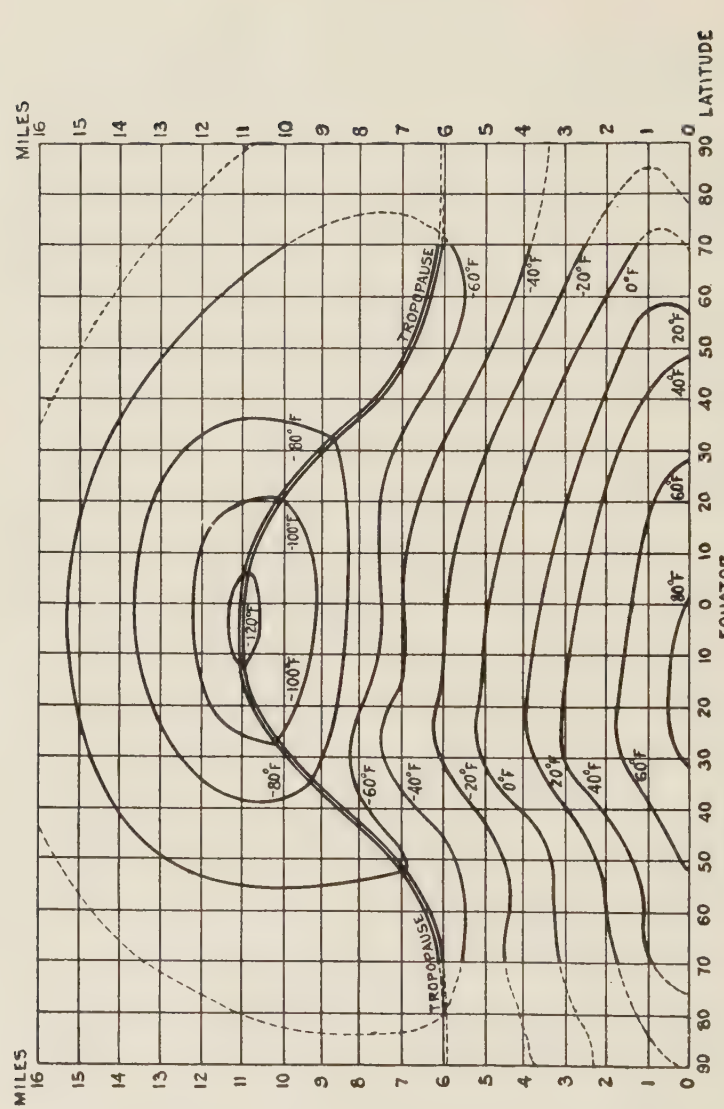


Fig. (1). Average Variation, with Altitude, of Temperature, Pressure, and Density (Middle Latitudes).

Fig. (2). Two Examples of Actual Temperature Lapse Rates as Determined by Aerograph Soundings (Full Lines).



VERTICAL DISTRIBUTION OF TEMPERATURE ALONG A MERIDIAN.

Dotted lines are based on very few observations. (After *Shaw* and *Ramanathan.*)

condensation will begin. When water vapor is condensed the latent heat of vaporization is made available to heat the air. While condensation is taking place, therefore, the temperature of rapidly rising air is reduced only at about half the dry adiabatic rate, or at 2.8° F. per 1000 feet. The *saturated* or *wet adiabatic lapse rate* amounts to a 2.8° F. decrease in temperature per 1000 feet increase of height.

Vertical temperature distribution in the atmosphere is mentioned here briefly because many weather situations may be explained thereby. Depending upon its lapse rate air may be in a state of equilibrium, or it may be stable or instable.

Air is in a *state of equilibrium* when its vertical temperature distribution is such that an air particle will remain at rest at whatever level it may be moved to. (This is not a common condition.)

Air is *stable* when its vertical distribution of temperature is such that an air particle will resist displacement from its level. (This condition exists in warm air masses, to be defined later, and is characteristic of foggy or hazy conditions.)

Air is *instable* when its vertical distribution of temperature is such that an air particle, when given either an upward or a downward impulse, will tend to move away from its original level with increasing speed. (This condition exists in cold air masses, to be defined later, and is characteristic of air with cumulo type clouds.)

Figure 1 Plate **170** is a simple temperature-height diagram illustrating lapse rates. It includes the average lapse rate, dry adiabatic lapse rate, and the wet adiabatic lapse rate. Figures 2 and 3 are additional, simplified, temperature-height diagrams illustrating stability and instability.

The solid line represents the existing lapse rate at a given time. The stable condition, Fig. 2, shows the actual lapse rate to be less than the dry adiabatic lapse rate. In this case rapidly rising air would cool off at the dry adiabatic rate and become increas-

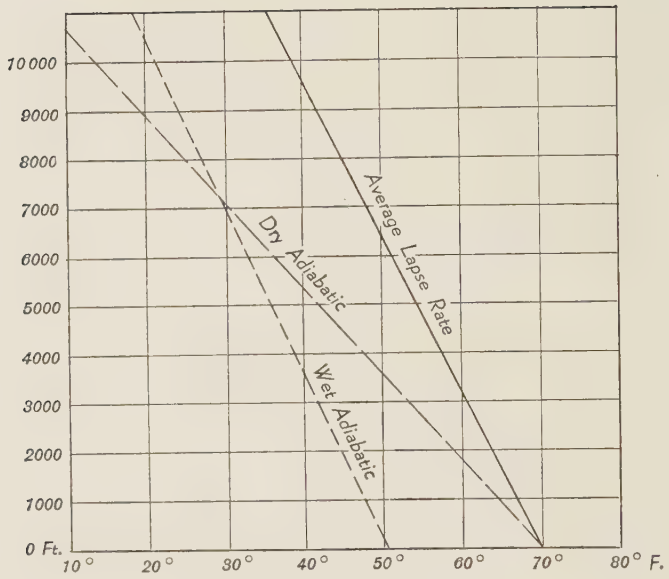


FIG. (1). LAPSE RATES.

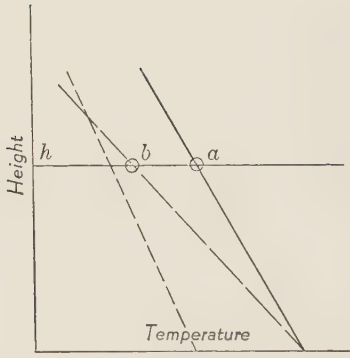


FIG. (2). STABLE LAPSE RATE.

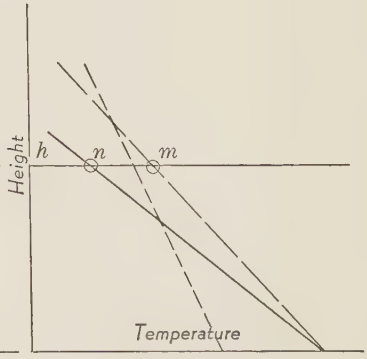


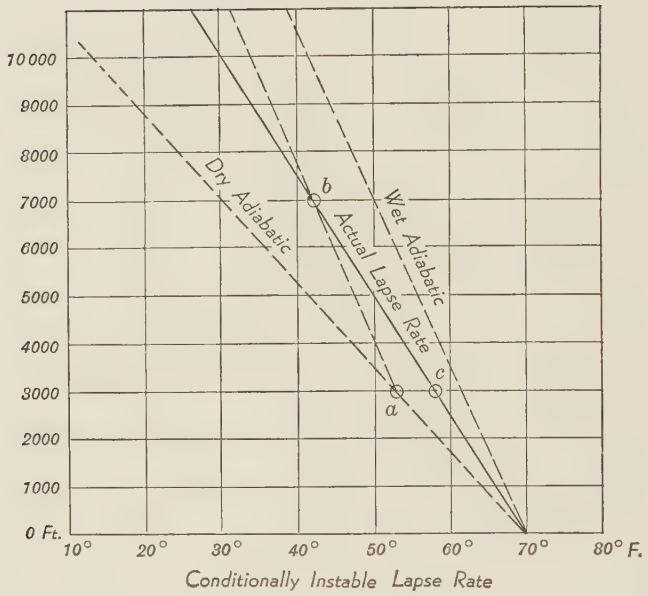
FIG. (3). INSTABLE LAPSE RATE.

ingly colder than the surrounding air through which it was rising. That is, if surface air were lifted to height "h" then the rising air would be colder by the amount a-b than the surrounding air. The colder air would be denser than the surrounding air, hence it would resist rising and would sink to its original level. The instable condition, Fig. 3, represents the actual lapse rate as greater than the dry adiabatic lapse rate. Rising air under this condition would cool off at the dry adiabatic lapse rate, but in rising becomes increasingly warmer than the surrounding air. That is, if surface air rose to height "h" then the rising air would be warmer by the amount m-n than the surrounding air. As the warmer air is less dense than the surrounding cooler air it would continue to rise, and hence is instable.

In the two illustrations of stability conditions given, the water vapor content of the air was assumed to be so low that condensation did not occur. There is an equilibrium condition between the two which have been so far illustrated.

In Plate **171** the solid line represents an actual lapse rate. Let it be assumed that the water vapor content of the surface air is such that saturation will occur at 53° F. Consider that some surface air is forced to ascend. It will cool at the dry adiabatic rate until saturation occurs at 53° F. This takes place at 3,000 feet, *a* on the graph, and condensation commences. With further ascent of the air it cools at the wet adiabatic rate. At *a* the temperature of the ascending air was 53° F., about 4° cooler than the temperature of the surrounding air, represented by the point *c*. Hence at this point the air is stable. As this air is continued to be forced upward it remains cooler than the surrounding air until a height of 7,000 feet is reached, at the point *b*. Above *b* the rising air becomes warmer than the surrounding air and hence from this point on is instable. Such a lapse rate, as has just been illustrated, is one of *conditional instability*. Therefore, a *conditionally instable lapse rate* is defined as a lapse rate which is stable up to a certain height, but above this height is instable

Plate No. 171


10 000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0 Ft.
10°
20°
30°
40°
50°
60°
70°
80° F.
Dry Adiabatic
Wet Adiabatic
Actual Lapse Rate
b
c
a
Conditionally Instable Lapse Rate

because condensation taking place introduces the wet adiabatic lapse rate for ascending air. It now becomes apparent that the water vapor content of the air is an important factor in the stability of the atmosphere.

A common occurrence in the atmosphere is a lapse rate in which the temperature increases with height instead of decreasing. This condition is called an *inversion.* Inversions occur at various heights in the atmosphere and at the earth's surface. The layer of air involved in an inversion usually is not very thick.

VI. Heating the Atmosphere.

The sun is the source of the heat supplied to the atmosphere. The atmosphere is almost transparent to the sun's direct radiation, which is a short wave radiation, and therefore receives only a very small amount of heat directly from the sun. Much of the sun's radiation is absorbed by the earth's surface. The atmosphere in turn gets its heat from the earth's surface.

The earth radiates heat in long wave radiation. The water vapor of the atmosphere and the water of the clouds absorbs some of the earth's long wave radiation. The water vapor in turn radiates its absorbed energy, some of it back to earth and some out into space.

The atmosphere acts like the glass of a greenhouse. Incoming short waves of solar radiation are passed through freely. Outbound long wave radiation is impeded. The result is a rise in temperature, both in the case of the greenhouse and the lower atmosphere.

The lower layers of the atmosphere are heated also by conduction, that is by direct contact with the earth's surface. The heating effect on the atmosphere over land is different than over the oceans. The differences will be described briefly.

Over land at the end of the night the ground temperature will be low, having steadily cooled during the night due to loss of heat by radiation into space. The air layer near the surface will have

been cooled by contact with the ground. Accordingly, stable conditions will have been established.

The lapse rate of the atmosphere at sunrise is represented by the curve *S*, Fig. 1, Plate **172**. After the sun is up the sunshine heats the ground, which in turn heats the air in contact with it. This process continues until the lower layers of the atmosphere reach or exceed the adiabatic lapse rate. In this manner an instable condition is arrived at and vertical currents are set up due to the instability. Around noon and early afternoon, due to continued heating of the ground and the vertical currents that have been established, a lapse rate such as represented by curve *N* is established.

Vertical currents, also called *convectional currents* or simply *convection*, may consist of a general churning up of the air over a large area, or may consist of rising, separated air columns. In the latter case the rising air is replaced by inflowing air and slow settling of air. When there is sufficient water vapor present condensation will be produced and the tops of the rising air columns will be marked by cumulus type clouds.

About mid-afternoon the heat radiated by the ground equals and then exceeds the heat received from the sun, so the ground temperature commences falling. Falling ground temperature results in lower surface air temperature. By sunset a stable lapse rate will have been established once more as represented by curve *E*.

Over the oceans there is not the same range of temperature changes that occurs over land. The day to night range of temperature over land varies greatly. It may amount to as much as 40° F., and will average about 20° F. for many temperate zone locations. Over oceans, however, observations show that the differences between day and night sea water temperatures do not exceed 1° F. Surface air over the oceans therefore, is not subjected to the same range of heating and cooling at the surface which exists over land areas.

Plate No. 172

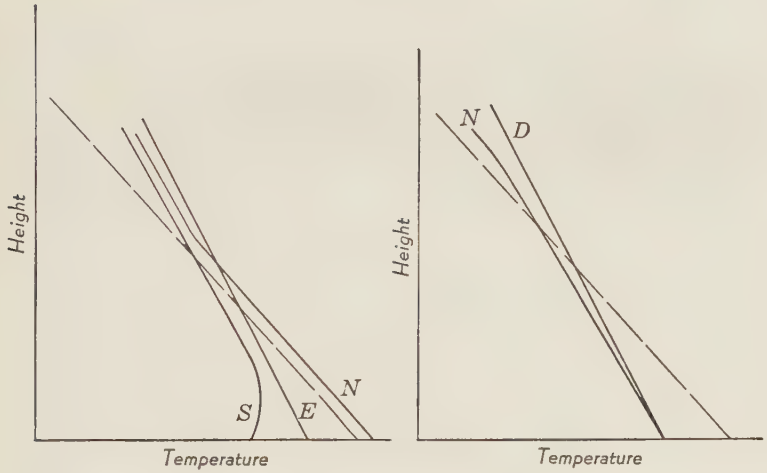


Fig. (1). Lapse Rates Over Land.
S—Sunrise
N—Noon
E—Sunset

Fig. (2). Lapse Rates Over the Ocean.
D—Day
N—Night

Except when the sun is nearly overhead most of its radiation to the surface of the sea is reflected back to space. As the sun approaches the meridian less of its radiation is reflected by the sea and much of it is absorbed by the ocean water. However, the sun's radiation penetrates to a considerable depth before it is completely absorbed. Whereas, over land only a few inches of the surface absorbs all the radiation and has its temperature considerably increased, over the sea several fathoms of water absorb the radiation and the temperature increase of the water is very small. Also, the specific heat of the water is about four times that of surface soil and this fact helps to explain the small temperature increase of the ocean surface. Still another factor which acts to prevent temperature rise of the ocean surface is that some of the heat received is used in evaporating water. The salinity of the surface layer increases due to evaporation and the density is increased thereby. The denser water then sinks and is replaced by cooler water from below.

At night the sea surface loses heat by long wave radiation to space. The surface water cools, but on cooling it becomes denser and it descends and thus spreads the cooling effect through an appreciable depth. Hence there is only a slight decrease in the surface temperature of the sea at night.

Due to the regulating effect of nearly constant sea water temperature on the surface air temperature, the atmospheric lapse rates over the oceans are quite different than those over land. Over land, instable lapse rates are probable during the day, especially after noon. Over oceans, on the contrary, the day lapse rates are more often stable while instable lapse rates may occur late at night. Due to instability conditions thunderstorms occur most frequently in the afternoon over the land and late at night over the sea. This is caused by radiation effects in the upper air. Lapse rates over the ocean are illustrated by the curves of Fig. 2, Plate **172.** The day lapse rate is represented by the curve *D*, and curve *N* represents the night lapse rate. Both curves

indicate practically the same temperature air at the surface. The daytime curve *D* indicates stability. The night curve *N* indicates an approach to an instable condition as the temperature in the upper air is lowered by radiation, and at the same time the surface air temperature remains constant.

Air is in constant horizontal motion over the earth's surface. Depending on whether the surface over which it is traveling is colder or warmer than the air, the air will be subjected to cooling or heating in contact with the earth's surface. To understand weather processes it is necessary to comprehend something of the cooling and heating process that takes place in traveling air masses.

An air mass is called a *cold air mass* when it is colder than the surface over which it travels. Such an air mass will be heated by the warmer surface and instability will result similar to that caused by daytime heating of air over land. Convection currents develop in a cold air mass which carry heat and moisture to higher levels. Sometimes over land, and always over the sea where there is a constant supply of water vapor, cumulo type clouds develop. High visibility is also a feature of cold air masses.

An air mass is called a *warm air mass* when it is warmer than the surface over which it travels. The warm air is cooled by the cooler surface and stable conditions develop. Vertical currents are prevented so that the cooling effect is confined to the lower layers of the air. Poor visibility, stratus clouds, and fog may be expected in the warm air mass.

Due to the daytime heating and night time cooling of land surfaces an air mass over land may be a cold air mass during the day and become a warm air mass at night. Over the oceans, however, where the sea surface temperature varies less than 1° F. between day and night, the diurnal change of air mass character is not experienced. A sudden change in sea surface temperature, common near coasts, may change the character of

an air mass. This is an important feature in understanding weather conditions at sea. Over tropical oceans the air temperature and sea surface temperature are so nearly the same that diurnal temperature changes control weather. That is, the night time cooling of the upper atmosphere by radiation and the small day and night change of sea surface temperature control the stability of the air over tropical oceans.

Mention has been made in preceding paragraphs of stability, and instability of the atmosphere. It was pointed out how the temperature lapse rate determined whether air was stable, instable, or conditionally instable. In general, instability is created in the lower atmosphere, either through the diurnal heating of the earth's surface by the sun, or through heating of air when it travels toward warmer regions. Instability produces cumulus clouds, showers, and thunderstorms.

Thunderstorms. When air is excessively instable thunderstorms may develop. Their formation will be described briefly.

As rain drops form near the tops of cumulonimbus clouds the drops rise or fall, depending upon their size and the strength of the ascending air currents within the cloud. The largest drops that form are about $\frac{1}{6}$ inch in diameter. An upward current of about 26 ft. per sec. (16 knots) holds up a rain drop of this size. It has been found that if larger drops form they are instable and immediately break up into smaller drops. The vertical currents in cumulonimbus clouds are not steady, but vary in gusts and lulls. Water drops rise and fall intermittently, growing in size and breaking up into smaller drops. Large drops fall as rain as they reach the edges of rapidly ascending air columns, or when the vertical velocity of the air is no longer sufficient to support them.

Hail often falls during a thunderstorm. The occurrence of hail confirms the existence of the rapidly ascending air currents in cumulonimbus clouds. A hailstone is found to consist of concentric layers of ice and snow. This indicates that hail is formed

by a succession of ascents and descents before finally falling to the earth. The temperature at the tops of the ascending current is below the freezing point. The drops are frozen here and snow gathers on the drops. Then, as they fall part way through the cloud during a lull, a coating of water gathers over the snow and ice. In an ascending current again, the drop is carried to the top of the cloud where ice and snow form once more. As the cycle is repeated the hailstone grows in size until it finally falls to earth.

It may be demonstrated experimentally that when water drops are broken up by air currents the smaller water drops take up a positive electric charge and the air takes up a negative charge. In a cumulonimbus cloud the ascending air breaks up water drops. The rising air, charged negatively, goes to the top of the cloud where a negative charge accumulates. The small water drops, now positively charged, lag behind, giving a positive charge to the middle and lower part of the cloud. Visible electrical discharges, lightning, may take place between different parts of the same cloud, between adjoining clouds, or between clouds and the earth's surface. The thunder which accompanies lightning is caused by the sudden expansion of the air along the path of the lightning. The distance at which thunder is heard is usually less than 10 miles, although distances up to 40 miles have been reported in extreme cases.

Inversions: An *inversion* has been defined as a condition where temperature increases with height, contrary to the normal condition. Inversions occur readily at the earth's surface over land during calm and clear nights. The ground cools rapidly by radiation and cools the air in contact with it. The lack of wind prevents mixing of the cold air with air above, so a cold surface layer of air develops with warmer air above. This is usually a shallow inversion but during long winter nights at high latitudes this type of inversion may build up to 5000 feet. Surface inversions over the sea may develop as a warm air mass travels over

the cooler sea surface. In both cases fog will form provided water vapor content of the cooled air is sufficient.

Inversions in the upper air may develop at various heights due to descending air which spreads out horizontally. The air is warmed by descent and spreading out creates a layer of air warmer than the air below it.

The air of an inversion is extremely stable. In fact an inversion in the upper air may be considered as a lid which prevents convective currents from passing through. This feature accounts in part for the varying diurnal range in temperature over land.

A low inversion, say at 500 feet above the surface, allows only 500 feet of air to absorb all the heat provided at the surface during the day time. With this condition at San Diego, the diurnal range of temperature is about 15° F. A higher inversion, say at 1500 feet, allows 1500 feet of air to absorb the day time surface heating. Under this condition the diurnal temperature range is about 7° F. at San Diego.

Diurnal heating quickly destroys surface inversions and low inversions. High inversions may persist day and night for long periods. Dust, smoke, and condensation nuclei mentioned in a previous paragraph, gather under inversions. Their presence is indicated by a layer of haze which gathers at the base of the inversion. This haze, not distinguishable as such from the surface, will interfere seriously with vertical visibility both from above and below.

Stratus Cloud Formations. Fog may accompany a surface inversion. It occurs when air is cooled below its dew point, and with proper wind conditions. Over land, with very little wind, condensation at the surface results in a dew or frost deposit. With a wind of about 4 to 10 knots, there will be sufficient turbulence to mix and cool a thin layer of surface air. As condensation occurs the condensed particles are mixed through the thin layer of air, producing a surface fog. With wind above 10 knots there is more turbulence and subsequent mixing of a

deeper layer of air. The air cooled at the surface is now carried to a considerable height by turbulence. Sufficient further cooling takes place in this upward movement to cause condensation. This condensation produces stratus clouds.

At sea, a warm air mass traveling over a cooler surface may produce a shallow fog in light airs. There will be just enough turbulence to mix the cooled air and sustain the fog particles through a height of 100 feet or so. With a recently formed, thin fog in light airs a sudden increase of wind speed may be expected to dissipate the fog. However, when a warm air mass has traveled at moderate to strong speed for a long way over a cooler ocean surface, turbulence will mix the cooled surface air to a height of 1000 feet or more. When fog finally forms it may extend up to the top of the turbulent mixing. Accordingly, when fogs do form in moderate to strong winds they are usually quite thick and persistent.

Heating by the sun and turbulent mixing tend to dissipate a thin fog. Sometimes stratus clouds form following the dissipation of the fog. Deep fogs do not dissipate readily. Over land, the combined effect of diurnal heating of the sun and turbulence may cause a deep fog to lift to become a low layer of stratus. Over the ocean, however, except along the coasts, this is less likely to occur as there is less diurnal heating effect.

Low stratus may be expected to dissolve during the day. High stratus will more often persist day and night. Diurnal heating and turbulence set up by the wind are the factors which affect the clearing of stratus. As stratus breaks up it may form stratocumulus if it forms lumps or rolls as it is broken up by turbulent air.

The California Fog. Along the coast of California, during the summer and fall, there is a more or less permanent inversion at heights of from 500 feet to 2000 feet above sea level. This inversion persists due to cold water along the coast which maintains a cool surface air temperature, and a flow of warm air aloft

from desert regions of southwestern United States. The cold water along the coast keeps the surface air cooled close to the saturation temperature so that the night time radiation effect readily produces condensation. Usually there is sufficient wind to mix the air by turbulence and produce stratus clouds as the condensed water droplets gather under the inversion.

With very low inversions fog will form. Fog and low stratus usually burn off during the forenoon. With high inversion, the time of clearing is progressively later during the day. Occasionally, when a very thick fog or stratus has formed clearing will not occur during the day.

VII. General Circulation.

When air is heated it expands. The air in the equatorial region receives more heat than the air in the polar regions. The expansion of air over the equatorial region is greater than the expansion over the polar regions so that the top of the equatorial atmosphere extends upward higher than the top of the polar atmosphere. The flow of air is therefore from the top of the equatorial atmosphere toward the poles. This flow occurs for the same reason that water flows from a higher surface toward a lower surface.

The air which flows from the top of the equatorial atmosphere toward the top of the air over the poles acts to increase the surface atmospheric pressure at the poles and to decrease the surface atmospheric pressure at the equatorial region. This is understood when it is recalled that the atmospheric pressure is due to the weight of the air above a given point. Removal of air lowers the surface pressure in the equatorial region. The addition of air increases the surface pressure at the polar regions. The process establishes a pressure gradient at the earth's surface from the poles to the equator, and a surface flow of air from the poles to the equatorial region should set in.

Were it not for the fact that the earth revolves, and assuming

an earth of homogeneous surface, the atmospheric circulation might consist of the simple circulation outlined in the two preceding paragraphs. That is, there would be ascending air over the equatorial region, an upper current flowing polewards, and surface currents flowing equatorwards. The effect on the earth's rotation on the circulation of the atmosphere will now be considered.

Any body moving over the earth's surface, including an air particle in a current of air, is acted upon by the deflecting force of the earth's rotation. The effect of this deflecting force is to cause the moving body to turn to the right in the northern hemisphere and to the left in the southern hemisphere.

The effect of the deflecting force due to the rotation of the earth may be understood by considering the effect on moving air of the varying linear velocities on the earth's surface. At the equator the eastward velocity of the earth's surface is about 910 knots. At the poles the linear velocity is zero. At intermediate latitudes the linear velocity is the product of the cosine of the latitude multiplied by the equatorial linear velocity. Air starting northward from the equator has, in addition to its northward velocity relative to the earth, the absolute velocity of 910 knots to the east. Neglecting friction this eastward velocity is retained. As the air moves northward its eastward velocity is increasingly higher than the eastward velocity of the earth's surface over which it moves. Relative to the earth, then, the northward moving air also moves eastward, or to the right. Air starting southward from the pole has no original linear velocity. As the air moves southward the localities on the earth's surface over which it moves have an increasingly higher eastward linear velocity. The southward moving air, therefore, lags behind, moving to the right, or west, relative to the earth's surface.

In Plate **173**, Fig. 1, the linear velocity at different latitudes on the earth's surface is graphically illustrated. The linear velocity is represented by the length of the radius of rotation at

Plate No. 173

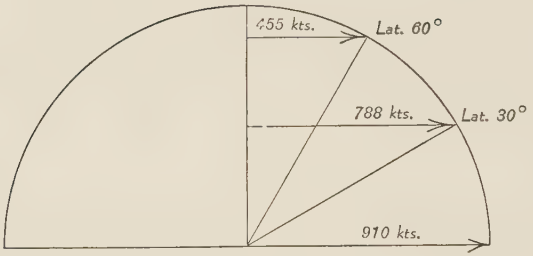


Fig. (1). Linear Velocity at any Latitude Represented by Radius of Rotation of Latitude.

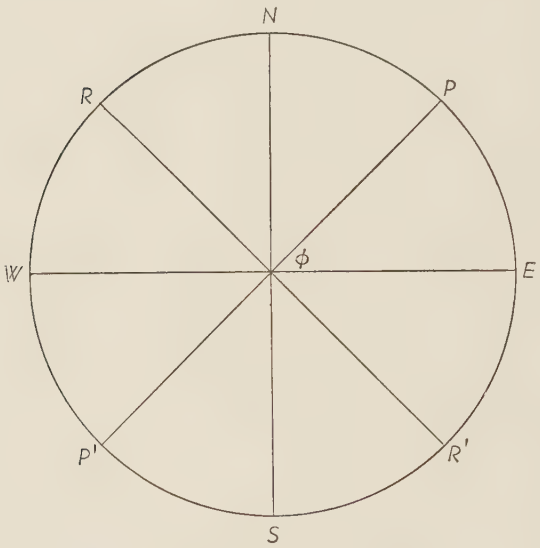


Fig. (2). *N-S*, Earth's Axis.

ϕ, latitude of any point *P*.
P-P', an axis through *P*.
R-R', an axis perpendicular to *P-P'*.

any latitude. The varying eastward linear velocities represented account for the deflection of north or south winds.

The deflective effect on the earth's rotation acts on all bodies moving in any direction along the earth's surface. The only exception to this general law is that at the equator the deflective effect of the earth's rotation is zero. To understand why the deflective force is operative on bodies moving in any direction it is necessary only to analyze the angular velocity at any point on the earth's surface such as P, at latitude ϕ, in Fig. 2, Plate **173.** The angular velocity acting on the point P may be broken up into components of angular velocity about the axis P-P' through the point P, and about the axis R-R' perpendicular to P-P'. It may now be seen that the effect of rotation about the axis R-R' on a moving body at P is similar to the effect on the moving body at the equator, that is, the effect on the component of angular rotation about the axis R-R' on a moving body at P is zero. The effect of the rotation about the axis P-P' on a body moving in any direction from P is similar to the effect at the poles of the earth.

The construction of Fig. 1, suggests, and it may be demonstrated mathematically, that the value of the component of angular rotation about the axis P-P' is directly proportional to the sine of the latitude. It has been determined that the strength of the deflective force due to the earth's rotation is dependent upon the speed of the moving body, the angular velocity of the earth's rotation and the sine of the latitude. The latter term is zero at the equator and increases to unity at the poles. There is, therefore, zero deflecting force at the equator and a maximum effect at the poles.*

* It is overlooked frequently that the deflective effect of the earth's rotation acts on ocean currents as well as on any other moving body. Theoretically, for a large body of water of infinite depth, the deflective effect on the earth's rotation makes wind driven surface water move in a direction 45° to the right of the wind direction in the northern hemisphere. Lower layers of water turn still further right.

Actually, bottom friction prevents attainment of the full deflection. The

Whenever a difference of atmospheric pressure is established on the earth's surface, air commences to flow from the higher to the lower pressure. But the deflecting force turns the moving air to the right. (Northern hemisphere is to be understood unless otherwise specified.) Movement to the right continues until the air moves perpendicular to the pressure gradient. The air will have attained a speed that is determined by a balance between the pressure force and the deflective force. The two forces are in opposite directions and the air moves in a direction perpendicular to the two forces.

When the wind has a speed which balances the pressure force and the deflective force it is called a geostrophic wind. It has been found that such speed depends upon the pressure force, so that with a given difference of pressure between two places a definite wind speed should result.

Pressure differences are represented by lines of equal pressure, called *isobars*. These lines usually are drawn for each 2 millibars or for each $\frac{1}{10}$ inch. When this is done on a chart or map on which the pressures at various stations have been entered, the isobars will show centers of high pressure, called *anticyclones*; centers of low pressure, called *lows, depressions,* or *cyclones*; and various other arrangements of isobars such as *troughs* of low pressure, *wedges* of high pressure, *cols*, and more or less *straight isobars.*

Pressure gradient is measured perpendicular to the isobars. The strength of the pressure gradient is inversely proportional to the distance between the isobars. As the geostrophic wind is proportional to the pressure gradient it is evident that crowded isobars call for strong winds.

Wind near the surface is less than geostrophic wind on account of surface friction. Friction effect decreases with altitude. At about 1500 feet the wind will be very close to the geostrophic

actual deflections observed amount to 40° to the right in the open sea, and 20° along the Atlantic and Pacific Coasts of the United States.

wind. At this level, and above, the wind flows parallel to the isobars. At the surface the wind speed will be less than geostrophic wind and will be deflected at angles up to 30° from the isobars. This deflection is toward low pressure areas and away from high pressure areas. Over the sea the deflection is less than over land.

In the northern hemisphere, face the wind and the low pressure area will be about ten points to your right (to your left in the southern hemisphere). When isobars are more or less circular, the wind apparently circulates around them. In the northern hemisphere this apparent circulation is clockwise around high pressure areas, and counter-clockwise around low pressure areas. In the southern hemisphere the two cases are reversed.

Maps of the mean pressure for January and July for the world are shown in Plates **174** and **175**. The average winds blow along and around the isobars in the directions indicated in the last paragraph. This, then, is not the simple circulation deduced in the opening paragraphs under General Circulation. The primary cause of the existing wind system is the different amount of heat received over the earth's surface. The rotation of the earth plus the irregular distribution of land and sea cause the modifications to a simple circulation from equator to poles and return.

To understand the general circulation, it should be remembered that the fundamental process taking place is an exchange of heat between equatorial regions and polar regions, and that the heat is being transported by moving air in the form of wind. There exists therefore, near the surface, north bound bodies of warm air and south bound bodies of cold air. Characteristic weather accompanies each of the air masses. At the boundaries between the warm and cold air various secondary circulations develop. These are the common storms of day to day weather.

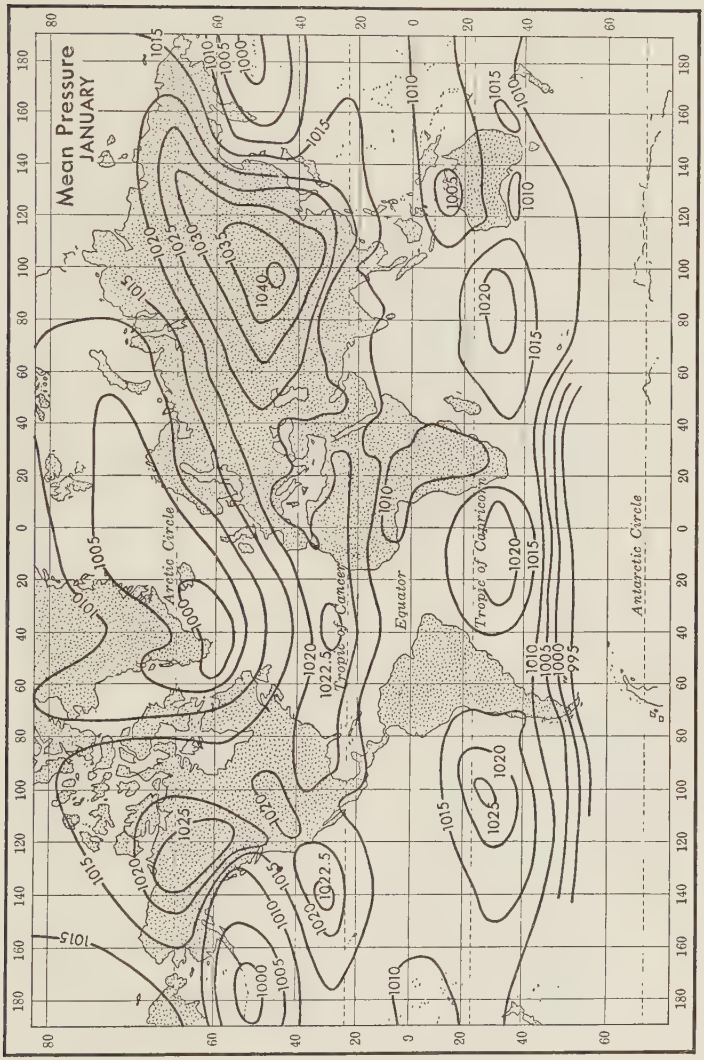
The mean winds resulting from the mean pressure distribution are shown in a simplified form in Plate **176** for the northern hemisphere. Around the equator is a belt of uniform low pres-

sure called doldrums. Here winds are light and variable, air is ascending, showers and thunderstorms are frequent. At about latitude 30° is a belt of high pressure, called *horse latitudes.* There is some descending air, winds are light and variable, and fine, dry weather generally prevails. The *trade winds* blow out of this high toward the equator, and on the northern side *prevailing westerlies* flow poleward. At about latitude 60° is a belt of low pressure. This is not as prominent in reality as the other features, though in the winter months it is well developed and it is marked by the presence of the *Aleutian Low* in the Pacific Ocean and the *Icelandic Low* in the Atlantic Ocean. There is thought to exist a small polar cap of high pressure at the poles. In any event, cold polar winds blow out from the pole as represented. The boundary between these polar winds and the warmer winds of the prevailing westerlies is called the polar *front.*

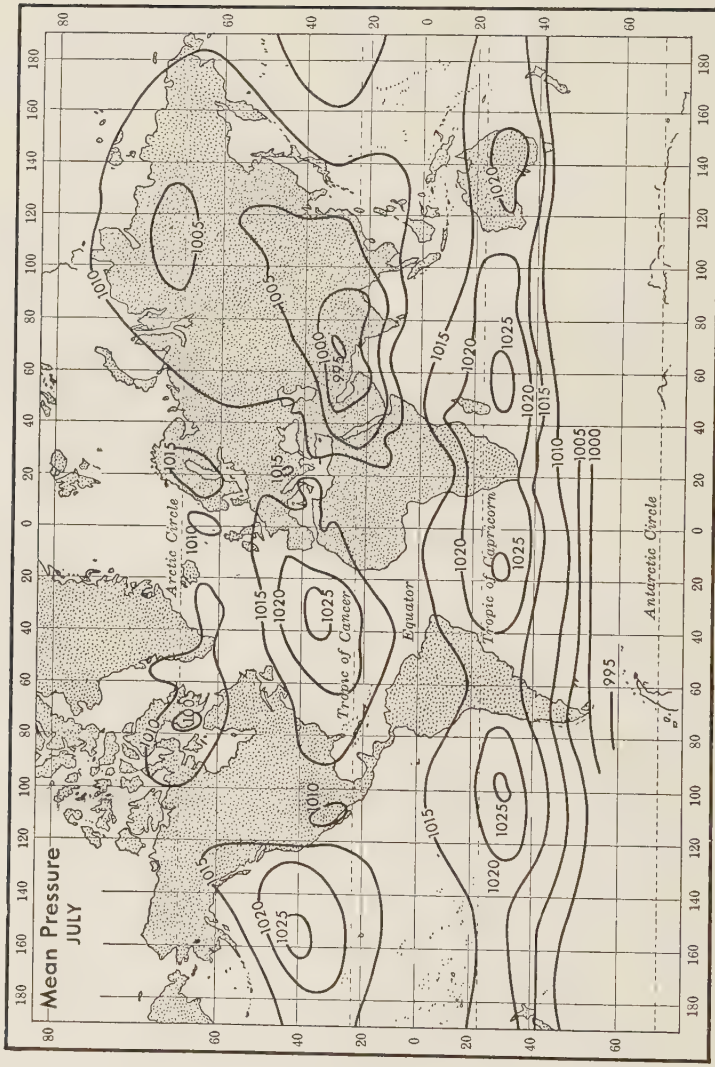
An attempt has been made in Plate **176** to illustrate the probable vertical section of the mean circulations. The *northeast trades* are represented as a shallow wind. Most of the air above the surface trade wind region is northbound air. The deflective force of the earth's rotation turns this air to the right, giving it an eastward direction. There is some sinking of this air and some poleward flow at high levels. The eastward flow of air above the *trades* plus the sinking of the air has a part in building up the high pressure belt of the *horse latitudes.*

It must be emphasized that Plate **176** is a simplified sketch of a mean condition. The pressure and wind systems represented do exist in general, especially so in the southern hemisphere where there are no large land areas. The northward and southward march of the sun as it changes declination during the year causes movement of the pressure and wind systems north and south with it. Ocean currents also help in the exchange of heat and in so doing modify the wind circulation.

It has been pointed out previously that the fundamental process taking place in the general circulation is an exchange of heat be-



ISOBARS OF MEAN PRESSURE FOR JANUARY.



ISOBARS OF MEAN PRESSURE FOR JULY.

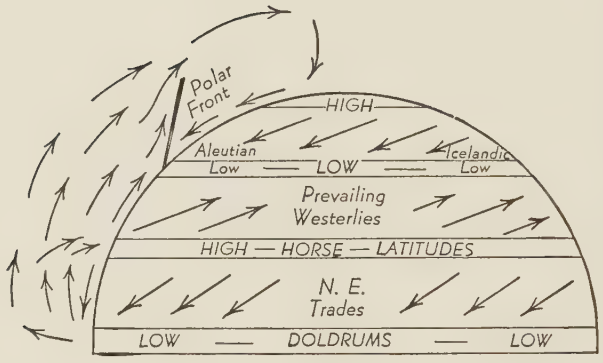
tween equatorial and polar regions. To illustrate probable conditions on a given day Plate **177**, as adapted from a sketch by V. Bjerknes, is used.

In Plate **177** is shown an idealized sketch of the general circulation on a given day. The atmosphere of the *troposphere* only is represented. The outer dashed line represents the *tropopause* or boundary surface between the *troposphere* and the *stratosphere*. On Plate **176** a *polar front* surface is represented, in the vertical, as separating the warm southwesterly winds of the middle latitudes from the cold northerly winds of the higher latitudes. In Plate **177** the *polar front* is shown as a wavy dashed line across the hemisphere with one tongue extending to the equator. This approaches reality. The extension of cold northerly winds occurs from time to time, especially in winter. "*Northers*," bringing freezing weather to Texas, Mexico, and felt as far south as the Panama Canal, are outbreaks of cold air from polar regions.

The wavy sections along the irregular *polar front* are low pressure areas, or storms. How the *lows* form on the *polar front* will be described later. It is sufficient to note here that it is along the *polar front* that the storm areas are located. The rotation of the earth prevents the direct flow of air between equator and pole. An exchange of air does take place, but in irregular flows and along devious courses. The *lows* along the *polar front* form important cogwheels in the complicated mechanism involved in getting warm air to the polar regions and cold air to the tropics.

The vertical sections on the eastern and western sides of the sketch of Plate **177** are not the same. This situation is a usual one in that there is a continual change in circulation from day to day and similar circulations on opposite sides of the earth are not to be expected. For a short period air from the tropics may have a more or less continuous path to the polar regions as represented on the eastern vertical section. But it must be re-

Plate No. 176



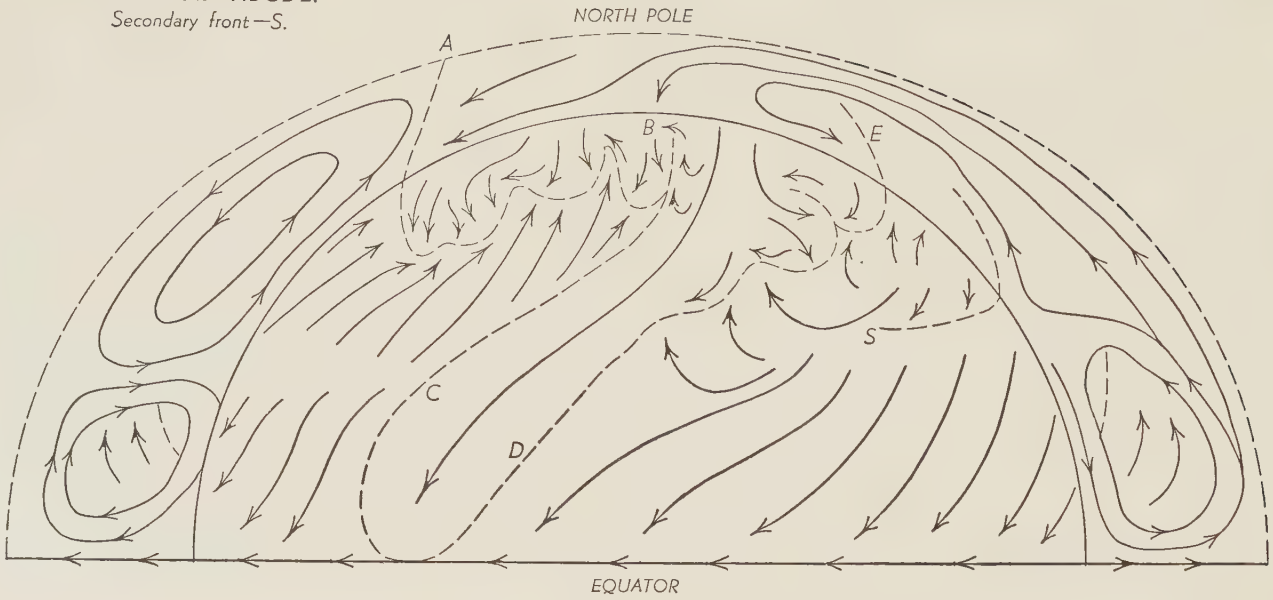
SIMPLIFIED GENERAL CIRCULATION

Plate No. 177

GENERAL CIRCULATION OF THE ATMOSPHERE

adapted from work by V. Bjerknes.

Dashed lines represent fronts.
Outer dashed line—tropopause.
Polar front—ABCDE.
Secondary front—S.



membered that only the northward component of the motion is represented here. The actual path of the air would consist of complicated spiral courses as the air moved northward as part of semipermanent and traveling pressure systems. The westward vertical section shows tropical air rising, flowing northward aloft, and then sinking into the high pressure belt of the *horse latitudes.* Some of the air from here returns equatorward as part of the trade winds, and some of the air goes on northward as a surface current, finally to come against the *polar front.* Here the air is forced upward, probably producing clouds and rain in a *low pressure area,* and then returns southward aloft.

The general circulation of the atmosphere is not simple, although simplification helps in understanding the fundamental processes at work. Large land areas modify the general features that have been so far outlined, changing or even obliterating the theoretical circulation over large areas. Continents heat rapidly in summer and cool rapidly in winter compared with the sea. Accordingly, low pressure develops over land in summer and high pressure in winter. The result is a seasonable wind system, toward the land in summer and off the land in winter. These seasonable winds are called *monsoon winds,* or simply *monsoons.* However, the term *monsoon* usually is applied to the seasonal winds of the Indian Ocean and the China Coast. The Asiatic monsoon system affects the wind circulation over a large area.

Along any coast there will be a daily *land and sea breeze* effect due to the daily heating and cooling of the land. This wind is a shallow one which extends only a few miles landward or seaward. The day breeze toward land is much stronger than the night breeze toward the sea. In high latitudes the general circulation is frequently so strong that, although modified, it is not replaced by the land and sea breeze. In lower latitudes, especially in the tropics, land and sea breeze is a regular daily weather feature.

VIII. Day to Day Weather.

The preceding paragraphs contained descriptions of the weather elements and general circulation and a few fundamental physical laws. Some knowledge of these three features is necessary to understand the existing weather, and in order to be able to understand the basis for predicting future weather. In the description of the day to day weather which follows, the principles of air mass analysis is used.

Air mass analysis of weather is based upon the fact that the general circulation of the atmosphere produces large masses of air whose properties are more or less the same over great areas. The region where an air mass develops is called its source. A study of the air mass at its source and its subsequent history provide the information necessary to understand weather processes.

As an air mass moves from its source gradual changes occur in its physical properties. The weather that is experienced within an air mass depends upon its source, the path traveled since leaving its source, and the speed of travel over its path. The three factors which determine the characteristics of an air mass at a given time are, accordingly, its source, path, and age. These factors will be considered briefly.

At its source a mass of air attains the temperature of the region and absorbs such water vapor as the temperature and the supply of water permits. At a source region air remains at rest or moves slowly over the region for many days. This condition is fulfilled in more or less stationary anticyclones (high pressure areas). Typical cold air mass sources are the stationary anticyclones over snow covered areas. These occur in polar regions, and over snow covered continents in the winter. The principal warm air mass sources are the subtropical anticyclones which make up the belt of high pressure at about latitude 30°.

When an air mass moves, its properties are changed according to the path over which it travels. The principal elements involved

in its path are whether it is over land or sea, and whether the surface is warmer or colder than the air.

The speed at which an air mass travels determines its age upon arrival at a given point. The faster the air mass travels the smaller will be the change in its properties. The change takes place from the surface upwards so that a rapidly traveling air mass, while modified at the surface, may not have its characteristics in the upper air changed appreciably before arrival at a given point. A slowly traveling air mass, on the other hand, will have its characteristics modified throughout.

Knowledge of the life history of an air mass is necessary to predict, or to understand fully, the weather that will occur within the mass. Without life history only the general weather that will occur at a given place in an air mass is understandable. Deviations from the general weather expected may be explained, usually, if the life history of the air mass is known.

There are two main types of air masses classified according to their source, *polar air masses* and *tropical air masses.* Cold air masses and warm air masses have been defined previously. A *polar air mass* usually is a cold air mass and a *tropical air mass* is usually a warm air mass. However, in middle latitudes this may not be the case always. It should be remembered that a *cold air mass* is one which is colder than the surface over which it travels and a *warm air mass* is one which is warmer than the surface over which it travels, regardless of the source in either case.

Whether an air mass has traveled over land or sea is an important factor so the distinctive terms, continental or maritime, are used to amplify the classification of air masses. That is, a cold mass of continental polar air is quite different than a cold mass of maritime polar air, though each has many common properties.

Further classifications of air masses are sometimes made for special reasons. Some of the distinctions are due to real, but

minor, differences in the air masses designated and some distinctions are made for convenience only. Arctic air and equatorial air may be used to designate air from the arctic regions and doldrums respectively, rather than from the more general regions indicated by polar air and tropical air. Geographical names may also be used to identify air masses, examples being: Tropical Atlantic air, Polar Pacific air, Polar Canadian air, etc.

Cold Air Properties. Cold air mass sources are the polar regions throughout the year and snow covered continents in winter. At the source air is cooled from below and the mass develops the following properties: Low temperature, stable conditions, and low specific humidity.

As a cold air mass moves from its source it is heated from below, instability develops and spreads upward. Continued heating from below produces a steep lapse rate and convective currents result.

When the path of the cold mass is over the sea, moisture is picked up. The convective currents carry the moisture aloft. Cumulo form clouds develop and they soon change into cumulonimbus. When the path is over dry land convective currents develop as the air is heated at the surface but clouds do not form due to low moisture content. Varying cloud amount will form in a cold air mass moving over land that has some water available, such as a lake region or an area recently rain soaked.

To illustrate the foregoing, consider a cold air mass in winter moving off the Atlantic Coast in the vicinity of Cape Hatteras. The air may have entered the United States at North Dakota with a temperature of 0° F. In 48 hours the cold air has reached Cape Hatteras, where it arrives heated to a temperature of 40° F. There has been very little moisture to pick up enroute so the air has a low relative humidity. Therefore, along the coast the sky is cloudless, or a few scattered cumulus clouds may have developed. About 60 miles off shore the center of the Gulf Stream is reached. Moisture has been picked up and the warm Gulf

Stream has accelerated the heating from below. Cumulonimbus clouds will have developed and showers will occur in the air mass which was almost cloudless when leaving land.

In general, a cold mass over the ocean will be characterized by the following:

1. Increasing temperature and humidity as it absorbs heat and moisture during its travel equatorwards.
2. Steep lapse rate and instability as the air in lower levels becomes lighter due to 1.
3. Turbulence, gusts, and squalls.
4. Cumulus and cumulonimbus clouds.
5. Variable sky, clearing intervals between dark and threatening weather.
6. Showers with sudden beginnings and endings.
7. A slight diurnal variation in clouds and precipitation, with an early morning maximum.
8. Good visibility between showers.
9. Moderate height of cloud base, usually above 1,000 feet.

For a cold air mass over land the characteristics are compared with the maritime cold mass properties above in order to emphasize the significant differences.

1. Similar temperature increase, but the low humidity remains constant.
2. Similar steep lapse rate and instability.
3. Gusts and squalls to a minor degree, but not as evident as over the sea.
4. Similar clouds, cumulo form, but fewer, and often no clouds.
5. Similar variable sky, if clouds are present.
6. Few showers, and only under special conditions such as lee side of larger lakes, and over swampy or wet ground.
7. Pronounced diurnal period in cloudiness but with an afternoon maximum.

8. Good visibility decreasing considerably over dusty or smoky regions.

9. Cloud base is higher than over the sea, usually 2,000 feet or more.

When a maritime cold mass invades a continent in summer, the instability is intensified and showers increase in frequency and intensity. When the invasion occurs in winter, the instability decreases, the showers decrease in intensity, and the cumulus clouds begin to flatten out into bulging layers resembling stratus, stratacumulus, or nimbostratus. These influences spread upwards from the surface.

When a continental cold mass invades an ocean in summer it becomes more stable. When the invasion occurs in winter, instability is increased with subsequent increase of showers.

An old cold mass gradually develops toward a stable condition. It happens frequently, therefore, that a cold mass which has traveled across the Pacific Ocean arrives on the west coast of North America in a fairly stable state. Maximum instability occurs in air masses which move rapidly and directly from the cold source.

Warm Air Properties. The most important warm air mass sources are the oceanic subtropical anticyclones of the high pressure belt of the horse latitudes. Less important sources are hot continental areas in summer under anticyclonic conditions. At the source the maritime tropical air is warm at all levels with a high moisture content, and fairly stable.

As maritime tropical air moves to higher latitudes the air is cooled from below and the lowest layer of air becomes increasingly stable. An inversion often develops. With continued cooling the surface air may be cooled below its dew point, and form fog. Various wind speeds will cause fog of different thickness or cause stratus to form as has been explained previously.

In general, a maritime warm air mass will be characterized by the following:

1. Stable lapse rates and inversions in the lower layers.
2. Slight turbulence, steady wind.
3. Poor visibility.
4. High relative humidity.
5. Stratus clouds, mist or fog, and haze.
6. Drizzle.

Air from the doldrums, or from the western part of subtropical anticyclones, and warm air masses which develop over continents in summer usually are conditionally instable. When such air moves toward colder regions it becomes stable in the lower layers but remains conditionally instable at higher altitudes. Near the surface it has warm air mass properties, that is, it is stable. Higher up, however, it has instable properties, similar to a cold air mass. Tropical air from the Gulf of Mexico, flowing over the United States is of this type.

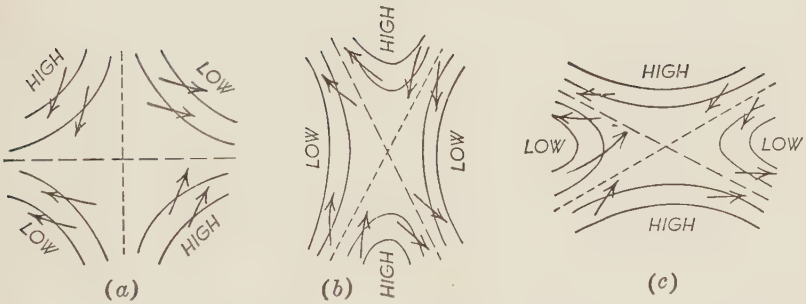
In the summer a maritime mass of warm air invading a hot continent develops instability, for the air mass now acts as a cold mass relative to the hot continent. In winter, however, with a cold continent, an invading maritime mass of warm air becomes more stable, and may develop a deep widespread advection fog.

IX. Traveling Disturbances.

The weather associated with different air masses has been described briefly. Weather which develops along the border between two adjacent air masses with different properties will next be described, as will be other weather features commonly classified as traveling disturbances.

The motion of air is controlled by the pressure distribution, which is represented by isobars on a weather map. As has been mentioned in a previous section the isobars arrange themselves

Plate No. 178



COLS. —THREE TYPES.— *Arrows indicate wind direction.*

in various forms or types. The three most important types of pressure distribution will be described in order, namely cols, depressions (lows or cyclones) and anticyclones (highs).

A *col* is the pressure distribution between two anticyclones and two depressions so arranged that the two anticyclones are diametrically opposite each other and the two depressions also are diametrically opposite each other. Plate **178** shows three types of cols. Air blows along the isobars so that within a col it may be seen that there are two main air currents blowing against one another and then being deflected sideways. The inflowing currents flow along the axis of inflow, dotted lines. The deflected current flows away along the axis of outflow, dashed lines.

When the *isotherms* (lines connecting points of the same temperature, not shown) are about parallel to the axis of outflow they are concentrated in the vicinity of this line, and a large, sudden temperature difference is created. When the isotherms are about parallel to the axis of inflow the isotherms are moved away from one another so that the temperature difference in the col becomes less and less.

Assume the axis of outflow runs east and west, and that the air to the south is warm and air to the north cool. The air movement of the col brings the warm and the cold air into juxtaposition. This would develop a marked discontinuity in temperature which would build up along the axis outflow. The process of creating such a discontinuity is called *frontogenesis*, and the discontinuity created is called a *front*.

With polar air on the north side and tropical air on the south side, the col brings polar air and tropical air together to form the polar front. The polar front is one of the principal features of the weather of the temperate zones.

The preceding simple explanation does not explain fully the intricacies involved in the formation of fronts. Frontogenesis

may occur also in other wind systems especially in troughs of low pressure. Most active frontogenesis occurs in the vicinity of cols and the fronts tend to be parallel to, and not far from, the axis of outflow. Temperature distribution determines whether or not a front will develop. If the isotherms are unfavorably arranged a col will destroy a temperature contrast rather than create one.

The weather associated with cols cannot be generalized effectively. The weather map for each case must be studied for the variety of weather accompanying it. However, it is usually found that cols of type (b) produce fair and settled weather while those of type (c) are usually followed by unsettled and bad weather.

The general circulation contains sources which form large masses of homogeneous air. The general circulation also tends to form frontal zones between the various air masses. Frontal zones are maintained where the air currents converge toward a line. In general, there are three main frontal zones.

The *equatorial frontal zone* is in the doldrums and separates the equatorial air of the winter hemisphere from that of the summer hemisphere. Due to the slight temperature difference between the two air masses involved, the frontal zone is not a pronounced one.

The *polar front* is the most important frontal zone. It separates tropical air from polar air. In the Atlantic, the polar front extends generally from the United States toward Norway. It moves northward in summer and southward in winter. In the Pacific the polar front runs from the coast of China toward the United States. There is extensive north and south displacement, summer and winter, respectively, of the polar front.

The third frontal zone develops between maritime polar air and colder arctic air farther north. This front is called the *arctic front.*

Fronts of lesser extent, called *secondary fronts*, may form within air masses principally between old and young maritime polar air. These fronts do not have the persistence or intensity of the three principal fronts. They do play an important part in weather, however, by complicating the frontal structure of many weather situations.

Along the fronts tremendous amounts of energy are concentrated. The temperature differences at the front are an index of the energy available. The heat energy is used by the air to create *kinetic energy* in the form of wind. Traveling depressions (lows, cyclones) develop along the fronts, using up the energy accumulated there.

The usual storm area of the temperate zone is an area of low barometric pressure. This area of low pressure is referred to variously as a *depression, low* or *cyclone*. The art of forecasting weather gradually developed during the latter part of the last century as knowledge was acquired of the general eastward travel of the depressions of the temperate zones. The average speed of travel of the depressions as well as the mean tracks of geographically classified storms, was used in forecasting future weather. Not much of the structure of the traveling depression was known.

Through studies of weather charts, J. Bjerkness and his associates in the Norwegian weather service reached the conclusion that the traveling depressions consisted of a sector of warm air surrounded by colder air, with a front (surface of discontinuity) separating the cold air from the warm air. Plate **179** shows a cyclone model as visualized by the Norwegian meteorologists about 1920. As may be seen in the plan view, the depression is made up of a sector of warm air surrounded, except to the south, by cold air. The depression has an easterly movement. The part of the front where warm air replaces cold air is called

the *warm front.* The western side where cold air replaces warm air is called the *cold front.*

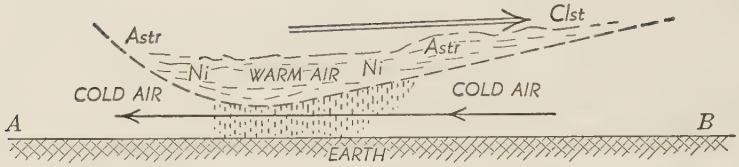
The lower figure of Plate **179** represents a cross section along the line *C D,* south of the center of depression. Here the cold air acts as a wedge under the warm air, on both east and west sides. To the east, warm air overruns the cold wedge. To the west the cold wedge is pushing under the warm air, lifting it. The inclination of the warm front surface is about 1 in 100 and the inclination of the cold front surface usually is greater, up to perhaps 1 in 50. The inclination of the frontal surfaces varies with the relative velocities of the air currents involved and with their differences in temperature.

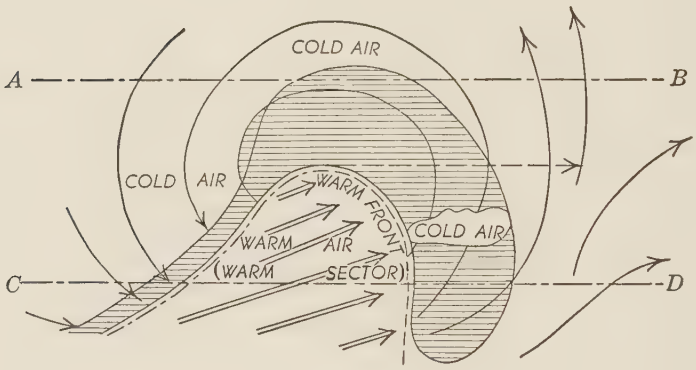
The upper figure of Plate **179** represents a cross section along the line *A B* north of the center of the depression. Here the cold air forms a valley partly filled with clouds.

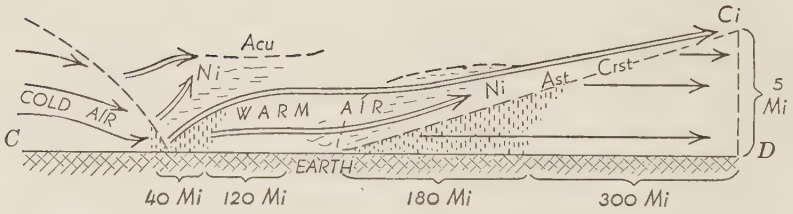
Warm air is lighter than cold air and therefore will readily rise above the cold air wedges along the frontal surface. The warm air blows up the warm front surface and in ascending expands and cools. After ascending high enough to cool the air to its saturation point, condensation begins and a cloud system develops in the warm air above the warm front surface.

At the highest part of the warm front surface, hence the most easterly part and the first part to be observed as the depression approaches, cirrus and cirrostratus develop. Frontal cirrus consists of bands and threads indicating their direction of movement. They merge into cirrostratus and altostratus as the front approaches. The altostratus becomes denser and lowers, becoming nimbostratus where precipitation sets in.

A warm front cloud system, observed from the earth's surface, has an even appearance, distinctly different from that of convectional clouds. Precipitation from frontal clouds is usually continuous and more or less constant in intensity. Poorly developed frontal systems may produce intermittent precipitation,


Clst
Astr
Astr
Ni
WARM AIR
Ni
COLD AIR
COLD AIR
A
B
EARTH


COLD AIR
A
B
COLD AIR
WARM FRONT
WARM AIR
(WARM SECTOR)
COLD AIR
C
D


Ci
Acu
Ni
COLD AIR
WARM AIR
Ni
Ast
Crst
5 Mi
C
D
EARTH
40 Mi
120 Mi
180 Mi
300 Mi

but the variations are less than in the case of showers from convectional clouds.

At the cold front surface the warm air is being lifted by the cold wedge of air. Condensation, clouds, and precipitation develop as along the warm front surface. However, due to the current above the cold front, its cloud system is displaced eastward and the upper (westward) part of the cold front surface is cloudless. The rain area at the cold front is narrow, 40 miles on the average compared to 180 miles for the width of the warm front rain area.

As described so far, the model depression is a simple one and for conditions when the air of the warm sector is stable, a frequent occurrence in Norway and the eastern Atlantic in general. Likewise, along the Pacific Coast of North America the warm sector air will frequently be stable. However, over eastern United States and off its Atlantic Coast warm sector air, originating over the Gulf of Mexico and to the eastward, frequently is conditionally instable. When the warm air is conditionally instable, cumulonimbus clouds with thunderstorms may develop with the warm front clouds, in the warm sector, and at the cold front.

Not only is the cyclone model of Plate **179** an "ideal depression," but it represents only one stage in the life history of a depression. Continued studies by Norwegian meteorologists have shown that a depression originates as a slight wave on a front and that the wave moves along the front, steadily growing in amplitude. After some time the wave develops to the stage represented by Plate **179**. Plate **180** represents the principal stages of a depression. In (a) the front at the surface is a straight line, an easterly warm current to the south and a westerly cold current to the north. At the front the cold air is wedge shaped with an inclination of about 1 in 100. The warm air rests on the cold wedge and flows along it, but not up the wedge of

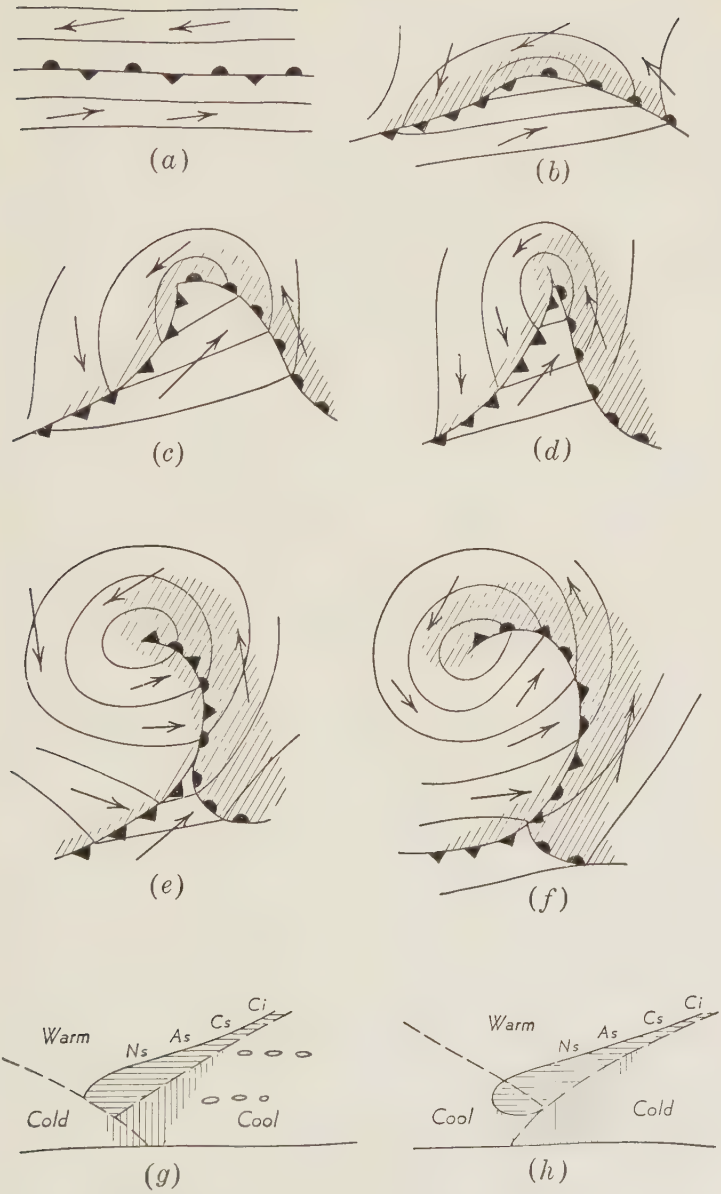
cold air. Hence there is no lifting of the warm air and no cloud system.

In (b) a slight wave has developed. The warm air now has a frontal surface to climb. Condensation, clouds, and precipitation will begin. With condensation, the release of heat of vaporization provides energy to aid in the development of the storm and to produce high winds.

Explanations satisfactory to everyone have not been produced to account for the commencement of the frontal wave. However, wave formation for purposes of illustration is comparable to waves produced on the sea by a strong wind. The wave produced on the frontal surface between heavy, cold air and light, warm air are very long waves of the order of 1000 miles or so.

Sea waves are usually stable waves, that is, they travel with a fairly constant amplitude, a swell on the open ocean for example. As a swell approaches a beach its amplitude increases and a ground swell is experienced. Further inshore the swell grows higher and higher to form a thin, sharp crest, finally breaking on the shore. Thus, the stable swell on the open sea with small amplitude, becomes instable as it approaches shore, increases its amplitude, becomes thin, and breaks on the shore. A frontal wave usually is instable. Once started, its amplitude increases and at the same time the cold front catches up with the warm front. This eliminates the warm sector at the surface. The process is called *occlusion* of the depression and the resulting front, where the cold front has reached the warm front, is an *occluded front.*

In (c) of Plate **180**, the wave has developed to the model form represented in Plate **179**. In (d) occlusion has just commenced. Note the changing shape of the precipitation area. In (e) a newly occluded depression is represented. In (f) an old occlusion is represented. The final stage after (f) is a frontless whirl of air.



DEVELOPMENT OF A DEPRESSION

Hatched areas are precipitation areas.

As an occlusion progresses the warm air is lifted higher and higher until it is cut off completely. Occluded fronts may act like either a warm front or a cold front. In (g), Plate **180**, the cold air to the west is the colder, so that not only the warm sector air but also the eastern air is lifted. This occluded front acts like a cold front. In (h), the eastern air is the colder so that the western air climbs up the colder eastern air. This type of occluded front acts like a warm front.

In the description of the model cyclone and the wave development of the cyclone, only a general, simplified description has been attempted. The complications that occur in nature to alter such a simple picture of a depression seem almost infinite. But when data are available practically all weather phenomena associated with the traveling depression of temperate latitudes may be explained as a variation of the cyclone model described.

Accurate weather reports enable a forecaster to analyze the current weather situation and to predict future development.

Frequently a storm will not consist of more or less circular isobars, which are usually associated with a depression, but will be a trough of low pressure. The isobars of the trough may be either V-shaped or U-shaped. The U-shaped isobars have no fronts in them but usually have unsettled weather, and a front may develop in U-shaped troughs. In V-shaped troughs of low pressure a front is always present. When such a trough passes, the meteorological elements vary abruptly.

At a frontal surface there is a discontinuity of various meteorological elements. That is, upon the passage of a front there will occur sudden changes in temperature, wind direction and in the character of the pressure change that is taking place. The change in wind direction, called wind shift, and the change in character of the pressure change are quite pronounced.

When a front passes, the wind always veers, that is, the change in direction is clockwise, and the change is more or less abrupt. Upon the passage of a warm front, for example, the wind might

shift from southeast to south. And upon the passage of a cold front the shift might be from south or southwest to west or northwest.

Along cold fronts the wind shift usually is more pronounced than along warm fronts, and abrupt changes of 90° or more are not unusual. At the same time wind squalls and violent turbulence may occur. With some rapidly moving cold fronts the cold wedge becomes quite steep due to friction at the surface, and overrunning of the cold air aloft may even occur. The overrunning cold air creates an instable condition and falling down through the warmer air below it creates strong convectional currents. If, in addition, the warm air is conditionally instable a long line of continuous thunderstorms will develop along the cold front. This long line of thunderstorms is called a *line squall.* In extreme cases tornadoes and water spouts may occur along the squall line.

The wind shift which occurs at occluded fronts may be well marked, but with old occlusions the wind shift may be slight, only 1 to 2 points at times. These may not be observed aboard ship unless care is used in observing the weather.

In the case of a depression at the stage of the model cyclone, Plate **179**, pressure will fall steadily as the warm front approaches. At the passage of the warm front there will be a distinct change in the rate of fall of pressure. While the warm sector passes over a station the pressure will fall very slowly or may even remain steady. Upon the arrival of the cold front the pressure suddenly commences to rise. The character of the pressure change for a three hour period preceding an observation is called the *tendency.* It is obtained from a barograph. Properly reported tendencies are essential to a correct analysis of a weather situation. In the case of a ship's tendency report the travel of the ship has to be allowed for by anyone using the report. There is also the *barometric tide* to complicate the use of tendency reports,

especially from the low latitudes where the barometric tide has a relatively large value. At latitude 30° there is a diurnal range of pressure amounting to 2.5 mb, fluctuating with a 12 hour period. The pressure is highest at 1000 and 2200, and lowest at 0400 and 1600 L.C.T. At latitude 60° the diurnal range of pressure has a value of only 0.4 mb. (The cause of the barometric tide is not understood).

Violent circular storms which occur in the tropics are known generally as *tropical cyclones.* They have nearly circular isobars with very strong winds circulating counter clockwise in the northern hemisphere and clockwise in the southern hemisphere. Tropical cyclones are called *hurricanes* in the western hemisphere and the South Pacific. They are called *typhoons* in the Far East, and *baguios* in the Philippines. In the Indian Ocean *cyclone* is the common name for a tropical cyclone. In all these localities these storms are identical in character. They vary in size from a few miles in diameter up to several hundred miles.

There is some evidence that tropical cyclones form along the equatorial, or inter-tropical front, as a wave, like the depressions form along the polar front. However, at the present time the available evidence concerning the formation of tropical cyclones is incomplete and inconclusive. There is but little doubt, however, that in whatever manner they form, thermal instability plays an important part in their development and existence as a severe storm. Tropical cyclones are of a seasonable nature and are most frequent at the end of the summer season in each hemisphere.

The winds associated with tropical cyclones are amongst the most violent that occur. The rainfall is torrential and tides are abnormal. The storms are essentially maritime and seldom penetrate far inland. However, islands in the seas frequented by them and continental coasts that lie in the storm path have to bear all their fury and occasionally suffer great damage.

Additional information on tropical hurricanes, together with rules for handling ships in hurricane waters is contained in the Appendix.

A *tornado* is a circular whirl of great intensity and small area, having a diameter from a few feet up to a mile. Wind speed in a tornado may exceed 200 knots. Tornadoes form along a strong cold front of the type which produces line squalls.

The pressure in the center of the tornado is much lower than the immediate surroundings. It is this low pressure, together with high winds that produces extreme destruction. Heavy rain, hail, thunder and lightning accompany a tornado.

Tornadoes do not last more than an hour or two. They occur most frequently, and in most violent form, in the Mississippi Valley of the United States. Comparatively mild tornadoes occasionally form in Europe and Australia.

If a tornado goes to sea it becomes a water spout. Or if tornado forming conditions exist at sea, water spouts may form. The true tornado is a cyclonic whirl; that is, the rotation of the air is counter clockwise in the northern hemisphere as is the case in the traveling depression and tropical cyclone. All water spouts are not cyclonic, however. Some of these form at sea under local thunder storm conditions and in these small water spouts the rotation of the air may be cyclonic or anticyclonic. A similar condition on land exists in the case of whirls of dust frequently observed on hot summer days.

An *anticyclone* is an area of high pressure as outlined by closed isobars. There are two types of anticyclones, the traveling anticyclone and the more or less permanent anticyclones of the tropics which make up the horse latitudes.

The wind in an anticyclone moves around the isobars in a clockwise direction in the northern hemisphere and in a counter clockwise direction in the southern hemisphere. The wind has an outward drift from the center of the anticyclone and the air thus removed is compensated for by slowly descending air at

higher levels. This descending motion tends to dissolve high or intermediate clouds. Generally clear and fair weather often occurs, therefore, in anticyclones over land. However, anticyclones do not always give fair weather. Gale winds often occur toward their outer part. Fronts may penetrate well into an anticyclone to cause clouds and rain. The traveling anticyclones (highs), are made up of the cold air which follows behind the cyclones, (lows). Over oceans these anticyclones, acting as cold masses, produce convection and usually showers, or even thunderstorms when the temperature difference between the air and the water is marked.

A *wedge* is an area of relatively high pressure, so called because the isobars inclose a wedge shaped area. Traveling wedges usually bring clearing weather as they pass a locality.

X. Analysis of Weather and Forecasting.

The basis of modern weather forecasting is the availability of widespread weather reports received by telegraph or radio from land stations and ships at sea. It is common practice for most countries, in time of peace at least, to broadcast weather information. The broadcasts include both forecasts and the weather reports from which the forecasts were prepared. Ships at sea may copy such radio weather reports and if desired may prepare their own weather maps. Meteorological training and experience are necessary to analyze weather maps and to predict future weather. However, observant seamen soon acquire varying amounts of practical weather knowledge. The preparation and study of weather charts will add to their knowledge of weather and will be of practical assistance in the interpretation of local weather.

Instructions for the preparation of weather maps are contained in the United States Weather Bureau's pamphlet, INSTRUCTIONS TO MARINE METEOROLOGICAL OBSERVERS, and also in Navy Department publications. Special weather maps and charts are available from the two sources above.

	C_H	
V	C_M	TT/Td
ww	(N)	PP
	C_L N_h	app
		W
		Kd

FIG. (1). ARRANGEMENT AT ELEMENTS AROUND A CIRCLE WHICH REPRESENTS THE POSITION OF THE REPORTING SHIP.

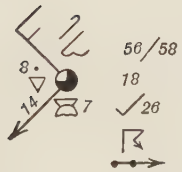


FIG. (2). WEATHER REPORT FROM SHIP AS PLOTTED FROM 7 CODE GROUPS.

FIG. (3). WEATHER REPORT FROM SHIP AS PLOTTED FROM 4 CODE GROUPS ONLY. CLOUDY SKY ASSUMED, NOT REPORTED IN 4 GROUP MESSAGE.

The weather report from each station is entered on the chart in numbers, letters and symbols. Different colored inks or pencils sometimes are used as well. The object is to enter a complete description of the weather at each station so that the separate features may be read easily. The complete weather report from a ship would be plotted as illustrated in Plate **181**.

Fig. 1 represents the position of the meteorological data as arranged when plotted around a circle located at the position of the ship or station making the weather report. The reports are received in a numeral code, details of which are contained in RADIO AIDS TO NAVIGATION, published by the Hydrographic Office of the Navy Department. In one form of ship report the group symbols of the radio message are arranged as follows:

YQLLL	111GG	DDFww	PPVTT	$3C_LC_MC_HN$	$T_dKD_kWN_h$	d_sv_sapp
10426	62412	28381	18856	33515	61695	55413

The letters above are the symbols which refer to the various elements reported. The numeral groups make up a sample message. The numerals are picked out of the weather code. With experience such a weather report may be decoded without reference to the code. As decoded the report would be entered as illustrated in Fig 2. The meanings of the symbols and the numeral code used is as follows:

Y is symbol for the day of the week; 1 is code for Sunday.
Q is symbol for the octant of the earth; 0 is code for north latitude, 0° to 90° W. longitude.
LLL is symbol for latitude; 426 is code for 42.6°.
111 is symbol for longitude; 624 is code for 62.4°.
GG is symbol for Greenwich civil time; 12 is code for 12^h G.C.T.
DD is symbol for wind direction by points; 28 is code for northwest.
F is symbol for wind force; 3 is code for Beaufort force 3.
ww is symbol for present weather; 81 is code for showers.
PP is symbol for pressure; 18 is code for 1018 millibars.

V is symbol for visibility; 8 is code for very good visibility.
TT is symbol for air temperature; 56 is code for 56° F.
3 is symbol for the code groups to follow. The four preceding code groups are always sent in the order given. Three different arrangements of the succeeding symbols are provided for. The particular sequence to follow is indicated by first numeral of the fifth group.
C_L is symbol for the type of lower clouds; 3 is code for cumulonimbus.
C_M is symbol for the type of middle clouds; 5 is code for altocumulus.
C_H is symbol for the type of high clouds; 1 is code for cirrus.
N is symbol for the total cloud amount; 5 is code for .7 to .8 of sky covered with clouds.
T_d is symbol for difference between sea and air temperatures; 6 is code for air temperature 2° F. lower than sea temperature.
K is symbol for the character of swell; 1 is code for low swell of average length.
D_k is symbol for direction from which swell is moving; 6 is code for west.
W is symbol for past weather for the 6 hours preceding the observation; 9 is code for thunderstorms.
N_h is symbol for total amount of lower clouds; 5 is code for .6 to .8 of sky covered with lower clouds.
d_s is symbol for ship's course; 5 is code for southwest.
v_s is symbol for ship's speed; 5 is code for 13 to 15 knots.
a is symbol for character of pressure change in preceding 3 hours; 4 is code for falling then rising with higher final pressure.
pp is symbol for amount of pressure change in preceding 3 hours; 13 is code for 2.6 millibars.

Only specially trained personnel will ordinarily be able to make use of such complete weather reports when they are available. Some broadcasts of weather reports send only the first four groups of the above message, and these may be all that inexperienced personnel will find it convenient to use. A weather report including only the first four groups of the foregoing

sample would appear when plotted as shown by Fig. 3, Plate **181**.

After weather reports are entered on a chart the analysis of the weather situation is made. A brief outline of the process of weather analysis will be given. After the analysis is made a forecast of future weather may be made. The accuracy of the forecast will depend upon the completeness and accuracy of the analysis. Weather analysis and forecasting is an involved art.

Accurate analysis rarely can be made on a single weather map. A succession of weather maps, at least two per day, for several days are required to indicate fully the true character of the air masses and fronts that may be present and their speed of travel.

To begin the analysis isobars are sketched in, drawing the isobars through points of equal pressure. Practice varies, but isobars may be drawn for each 2, 3, 4, or 5 millibars, or otherwise as desired. The isobars as drawn outline the position of the anticyclones and depressions. The exact position of the isobars should be interpolated between stations, and drawn with some regard to the wind directions. The wind should blow along the isobars with a slight deflection toward lower pressure. The isobars should be crowded where there is a strong wind. Using pressure alone, isobars around a depression would be sketched in as shown in Figs. 1 and 2, Plate **182**. This Plate represents weather reports from ships sending only the first four groups of the weather report previously described.

The next step in analysis is to examine the various weather elements to find fronts and air masses. The various elements that are important in locating fronts are the character of the three hour pressure changes (tendencies), cloud types, weather, winds, and temperature. Some of these elements are missing in the example given in Plate **182**. There are no tendencies and no cloud types reported. Rain is reported from three stations, indicated by two dots, and one station reports showers, indicated by a dot over a triangle. Some wind directions seem to blow away from the lowest pressure.

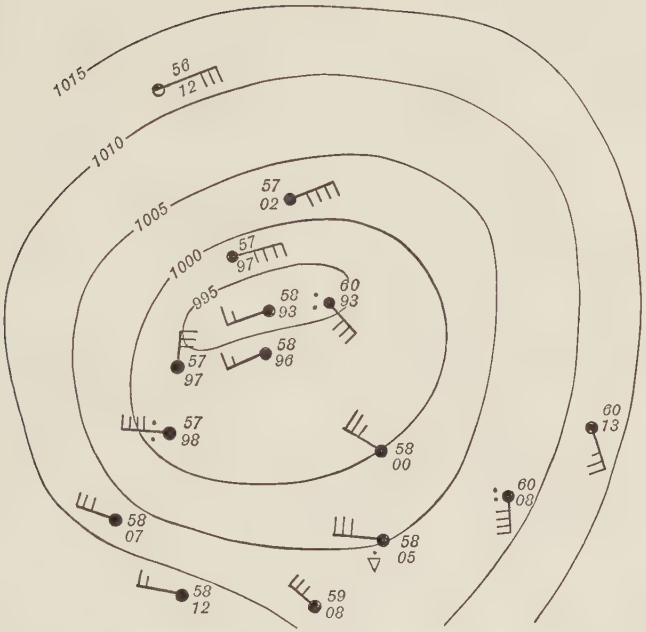


Fig. (1). Depression, Drawn on Pressure Reports Alone.

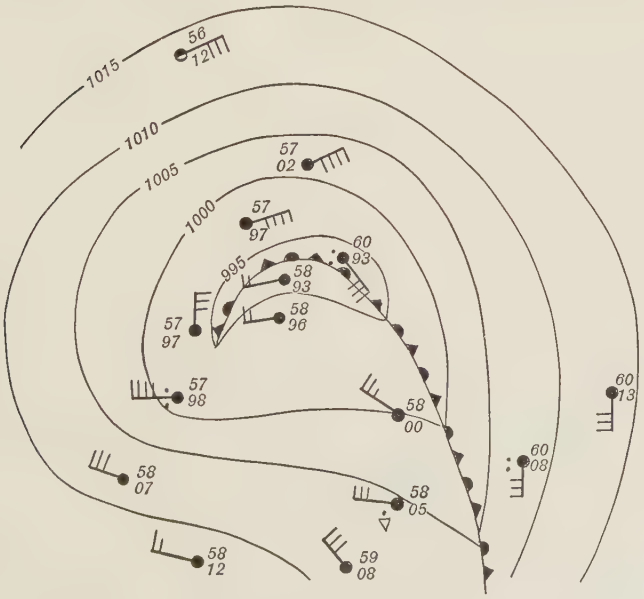


Fig. (2). Same Reports as Fig. 1 Depression Drawn With Probable Front.

With such information as is available, a front may be drawn and the isobars adjusted as shown in Fig. 2. Experience would indicate that the front is an occluded one of the type represented in (f), Plate **180**. Near the center of the depression one ship reports a pressure of 993 *millibars* (93); southeast, force six wind (3 long feathers on wind arrow); and rain (two dots). Nearby, two ships report cloudy weather with southwest, force 3 wind, (1 long and 1 short feather on wind arrow). The front is assumed to be between the light southwest winds and the stronger southeast wind and rain. In the lower right hand quadrant of the depression two ships report southerly winds, one with rain (2 dots); and two other ships report west and northwesterly wind, one also reporting showers (a dot over a triangle). A front is indicated here both by the winds and by the weather. That is, rain would be east of the front at the surface and showers would occur after the passage of the front.

The front is drawn on the evidence indicated. By trial and error it is fitted in between the stations indicated in such a manner that the resultant isobars are logical. Evidence is not conclusive that the front is an occluded one, as past history is not available. The west wind, force 8, with rain, (2 dots) at the end of the occlusion in the center is often experienced with this type of an occluded low and adds to the evidence that the front is an occluded one.

The temperature reports in this example are of little use, and, in general, surface air temperatures are less useful than other elements in determining the location of fronts. This example shows the eastern air to be slightly warmer than the western air. If this is the case then the occlusion is one similar to (g) in Plate **180**. Had this storm been followed for some days previous, the type of occlusion would be definitely known and more accurate forecasting would follow.

When the analysis of a weather situation has been completed the weather that is to follow may be forecast. The analysis will have shown, more or less completely depending on the extent and

character of the weather reports, the state of the weather at the time of the reports that have been charted. The weather to be expected will depend mainly upon the travel of the air masses, pressure systems, and fronts across the chart and upon the changes that will occur in these factors while they travel across the field of the chart.

Accurate forecasting requires a thorough knowledge of the physics of the atmosphere in order to understand, and hence predict, changes that may be expected in traveling air masses, pressure systems, and fronts. In addition to this knowledge actual forecasting experience is necessary to acquire the many tangible and intangible factors that make up the equipment of a successful forecaster. Over land, the terrain of the forecast area must be known in order to allow for local variations in weather due to irregular land areas. At sea, the scarcity of weather reports calls for considerable interpolation and deduction.

People who follow the sea have an excellent chance to observe weather and will find weather observation and study a useful, practical aid in their profession. The treatment of weather given in this chapter is hardly more than an introduction to the study of weather and an outline for subject matter to be covered. However, to encourage increased interest in weather this chapter is concluded with the following suggestions to be followed up by reference to the material of this chapter and to other works as well.

1. A knowledge of the properties of a cold air mass and a warm air mass will explain much weather.

2. Fronts will usually exist between cold air masses and warm air masses. Depressions form along fronts attended by typical cloud formation. See Plate **180**.

3. Weather, that is, cyclones and anticyclones with attendant weather, in the temperate zone travels in easterly directions, N.E. through to S.E. An understanding of the sequence of weather may be obtained from the cyclone model. See Plate **179**.

CHAPTER XXI

ASSISTANCE BY PUBLIC VESSELS TO VESSELS IN DISTRESS.

The following chapter has been kindly prepared by two officers of the U. S. Coast Guard [1] and gives the "Doctrine" of that Service as developed through many years of practical experience with the problems involved in rendering assistance to vessels in distress. (See Note at end of Chapter.)

One of the chief duties of the United States Coast Guard, in time of peace, is to render assistance to vessels in distress. The United States is the only nation that maintains a fleet of vessels whose primary function, during peace, is to afford aid to distressed vessels. A number of other nations maintain, or aid in the maintenance of, life-saving or lifeboat stations on shore to rescue the crews of stranded ships, but in none of these is the number of such stations so large as in the United States, nor are the stations part of a complete military organization as in this country. All seamen should be familiar with the character of assistance rendered by the United States Coast Guard, a work in which it has been engaged for many years with pronounced success.

The commanding officer of a vessel of the Navy will occasionally find himself in a position to render assistance similar to that extended by Coast Guard vessels. The purpose of this chapter is to set forth briefly what may be termed the "doctrine" of the Coast Guard with respect to certain cases that may arise, and the methods that have been found successful by Coast Guard officers.

Calls for Assistance. Assistance to a vessel in trouble at sea is rendered by one or more cruising Cutters [2]; if the vessel is stranded, help will be given by one or more Cutters and by the

[1] Rear Admiral H. G. Hamlet (Ret.) and the late Rear Admiral F. C. Billard.

[2] The cruising vessels of the Coast Guard, although of a size which places them in the Gunboat or Small Cruiser class when they act as a part of the Navy (in time of war), are technically designated as "Cutters."

crew of the nearest Coast Guard station on shore; reenforced, when necessary, by the crews of adjacent stations.

A vessel in need of assistance should, if possible, send word of her predicament by radio to the nearest shore radio station, taking care to give the exact location of the vessel, her condition, and sufficient data concerning the weather so that the probable drift of the disabled craft may be estimated. *The conventional S.O.S. signal should be used only in emergency cases,* because all the available resources of the Coast Guard are immediately directed in response to an S.O.S. call, and misuse of this urgent distress signal may serve to divert the assisting Cutters from other assistance work which may be, in fact, more urgent. All radio calls for assistance reach the operating officers of the Coast Guard and prompt action to afford assistance is taken, when the circumstances of the case warrant, to the utmost resources of the Service. Any change in conditions should be reported and, if it later develops that assistance is not needed, information to this effect should be immediately sent out. Cases have occurred where failure to cancel calls for assistance has resulted in a needless expenditure of fuel and time on the part of a Coast Guard Cutter. As it is the aim of the Coast Guard to answer all calls for assistance, it should be the part of mariners to cooperate by asking for assistance only when really necessary, by furnishing all possible information, by advising of changes in conditions as they occur, and by annulling the distress call when assistance is no longer needed.

Doctrine. The doctrine herein set forth is that which governs officers in command of Coast Guard Cutters, and is recommended for the guidance of the Commanding Officers of naval vessels in similar circumstances. In what follows, the term "Commanding Officer" refers to the officer in command of a United States naval vessel or Coast Guard Cutter; the word "master" means the captain in charge of a merchant vessel.

The case of a vessel in distress will usually involve either:

(*a*) Rescuing the crew from a ship in danger of foundering,
(*b*) Taking a disabled vessel in tow,
(*c*) Floating a stranded vessel.

In connection with the prevention of disasters to vessels,

there is the work of (*d*) removing or destroying floating menaces to navigation.

The Master of a vessel in distress at sea is responsible for the safety of the lives and property in his charge. Whether all or any of the people are to be taken off the vessel is a matter for him to decide. It is highly desirable, when a vessel is taken in tow in such condition that she is apt to founder, that all the personnel be taken off except only those absolutely necessary to handle the vessel; so that, should the vessel suddenly sink, the number of lives jeopardized may be reduced to a minimum. Whether or not the people are to be taken off is to be decided by the Master of the disabled vessel; the *manner* of taking them off is decided by the Commanding Officer of the public vessel assisting. The matter of rescuing property and personal effects is entirely in the hands of the Commanding Officer of the assisting vessel. In general, it is the function of the Commanding Officer to advise the Master of the distressed ship in the premises. If the master accept the advice tendered, the conduct of the operation lies solely with the Commanding Officer.

When a vessel is taken in tow, the question of *destination* often arises in connection with facilities for repairs, character of cargo, and other matters. The governing factor should be to get the vessel to the most practicable place of safety, taking into consideration the resources of the assisting vessel, the conditions of wind and sea, and any other circumstances; acceding, however, to the wishes of the Master in so far as is practicable, in the judgment of the Commanding Officer. It is the right of the Master to let go the tow line whenever he sees fit. Often, when a tow is nearing a place of safety, a commercial tow boat may come alongside and apply for the job of taking the disabled craft into port. In such cases it is the doctrine of the Coast Guard that it is not its function to interfere in any way with private enterprise. The Commanding Officer should see that the bargain proposed is fair and reasonable. If such be the case, in his opinion, he should let go the tow. Naturally, the Commanding Officer who possibly has picked up the tow under trying circumstances and has towed her successfully under great difficulties, feels a strong desire to complete the job by delivering his charge into a safe harbor. It must be borne in mind, however, that the rights of private enterprise which maintains

facilities for doing work of this character at large expense must be respected, and that the duty of the public vessel terminates when the element of danger to the ship and her people is removed.

The line of demarcation between the duties of the Commanding Officer of a public vessel and the right of private marine enterprise becomes more difficult to ascertain in the case of a stranded vessel. When danger to life is involved, it is, of course, the paramount duty of the public vessel to do everything possible to save life, regardless of any other question.

Suppose a vessel ashore is fallen in with, no other help in sight and no danger to life imminent. When communication has been established, the Commanding Officer proffers his advice based upon his experience in similar circumstances, having in mind that the responsibility for the welfare of the stranded vessel and for whatever operations are to be undertaken, if any at all, rests with the Master. It may be that the vessel is ashore among rocks and to pull her off might result in serious injury to her bottom, with possible danger of sinking in deep water. The Master of the ship must decide whether or not an effort shall be made to pull the vessel off at the time. It will generally be found that the Master of the stranded craft will follow the advice of the Commanding Officer of the public vessel there to assist him; so that it is very important that the advice given be based upon a careful study of the situation in all its aspects, having in mind that the actual decision must be made by the Master himself, as the responsibility is his, and his alone.

It may be that before passing a line to the stranded vessel a commercial wrecking vessel or tug arrives upon the scene. The duty of the Commanding Officer is first to permit negotiations between the tug and the Master of the stranded ship for floating the ship. The general principle is that the public vessel must make every effort to save the stranded craft, and at the same time not interfere with private enterprise. If the facilities offered by the tug are manifestly inadequate, the Commanding Officer would be justified in counselling the master of the stranded vessel to make no bargain except for the tug to *assist* the efforts of the public vessel. If, on the other hand, the facilities of the tug are reasonably adequate for the task, and reasonable terms are proposed, then the duty of the Commanding Officer is to notify the Master of the stranded ship that the public vessel will not engage

in the operations to the exclusion of the tug, but will assist as may be required.

The Coast Guard does not ordinarily undertake assistance work involving extensive wrecking operations or lightering. Its services in behalf of vessels in distress are rendered regardless of the nationality of the vessel assisted. Under the law, United States vessels may render aid and assistance to any vessel wrecked, disabled or in distress in the waters of Canada contiguous to the United States; and Canadian vessels may render aid and assistance to any vessel wrecked, disabled, or in distress in the waters of the United States contiguous to the Dominion of Canada.

Derelicts. In general, the removal of sunken obstructions or dangers to navigation *within the navigable waters of the United States* devolves by law upon the Secretary of War. The destruction or removal of wrecks, derelicts and other floating dangers to navigation *beyond the navigable waters of the United States* devolves primarily upon the Coast Guard by law. This is construed to include also the removal or destruction of sunken obstructions outside the navigable waters of the United States. Under the terms of an international convention, dated January 20, 1914, the United States and the leading maritime nations of Europe undertook to take all steps to insure the destruction of derelicts in the northern part of the Atlantic Ocean east of a line drawn from Cape Sable to a point situated in latitude 34 degrees North and longitude 70 degrees West. They also agreed to establish in the North Atlantic a service for the study and observation of ice conditions and a service of ice patrol. The Government of the United States was invited to undertake the management of the three services of derelict destruction, study and observation of ice conditions, and ice patrol, and the President designated the Coast Guard to carry out this work.

While the Coast Guard is especially charged with the destruction or removal of obstructions to navigation outside the three-mile limit, it is obviously the duty of the Commanding Officer of a naval vessel, if no Coast Guard vessel be available, upon falling in with an obstruction constituting a menace to navigation, to take appropriate action in the case.

Derelicts and other floating dangers to navigation, wherever found, should be taken to the most convenient port whenever

practicable. When it is not practicable to take a derelict or other floating danger into port, it should be destroyed or beached, care being exercised in each case that such destruction does not leave sunken or floating wreckage of such size or character as to constitute a menace to passing ships. If the derelict or other floating danger is to be destroyed within the navigable waters of the United States and the emergencies of the case permit, the Army Engineer Officer in charge of the district should be communicated with and consulted before final action is taken. Whenever circumstances make it necessary to destroy a derelict or other floating danger to navigation before consulting the Engineer Officer of the district, within the navigable waters of the United States, the Commanding Officer should promptly notify that officer.

When knowledge is obtained of any sunken obstruction to navigation within the navigable waters of the United States, Commanding Officers should promptly notify the District Engineer Officer and take no further action unless requested by that officer. The Commanding Officer should see that a wreck is properly buoyed or lighted before he leaves it. He should in all cases where wrecks are buoyed and lighted by him notify the nearest Lighthouse Superintendent of the fact, giving full information as to the character of the buoy or light established, and forwarding, if practicable, a section of the chart showing its position in order that such information may be published in the weekly Notice to Mariners.

A derelict may be fallen in with which is evidently of very considerable value. It then becomes necessary to decide whether an effort shall be made to tow the derelict into port or whether it shall be destroyed. If the duty upon which the public vessel is employed permits and the towing facilities are adequate, and the weather conditions promising, an effort should be made to tow the abandoned vessel into port. On the other hand, it may be that the derelict is directly in the path of commerce; it may be, for example, in the trans-Atlantic steamship lanes; weather conditions may be such that a considerable period will probably elapse before it can be taken in tow, with further danger that contact will be lost. In such a case, the Commanding Officer would be justified in promptly destroying the derelict regardless of any consideration other than the safety of lives

that might be jeopardized by collision between passing vessels and the derelict. The Commanding Officer should weigh carefully the matter before deciding to destroy what would be, if salvaged, very valuable property. But if, in his judgment, the possibility of jeopardizing lives by collision with the derelict outweighs the consideration of property value alone, he should not hesitate to sink the derelict. A floating derelict in the frequented paths of commerce is one of the greatest menaces to safety at sea, and the decision of a Commanding Officer on the spot to destroy such a menace is not open to question. The salvage of floating wreckage is not usually attempted, and such obstructions are ordinarily mined and destroyed.

When a derelict vessel is towed into port, it should be turned over to the custody of the owner if practicable; otherwise to that of the United States Marshal.

Rescuing the Crew from a Ship in Danger of Foundering. This subject is covered in Chapter XVIII and the practice of the Coast Guard is in accord with the general principles therein set forth. Usually, on a Coast Guard Cutter, two of the boats are surf boats, carried on davits in the waist, one on each side, equipped for lowering and hoisting and for work in rough water. In the waist is the logical place to carry such boats on a small ship because there is less pitch, the ship's rail is apt to be lower there, the boat is clear of the propeller, it gets the advantage of the lee formed by the forward or the after part of the ship, and generally a boat can be handled better along the straight part of the side of the ship and will be less liable to be stove as the ship rolls than if under the counter or the bluff of the bow. Also, on a small ship, the operation of lowering, hooking on and hoisting is directly under observation from the bridge, as it should be; particularly when getting the boat away or picking it up in a seaway.

The boat should never be lowered until the order to lower is given from the bridge, and great care should be taken to give the order at the most favorable time.

Obviously, the nearer the ship can be brought, with safety, to the wreck, the easier the task for the boat's crew and the less the danger to them. By careful maneuvering and watching the drift, it will be found that a vessel can be held much nearer to a drifting craft than would be thought feasible, particularly if held

with her stern clear in a position to increase distance when imperative.

In the equipment of a life-boat carried at davits, it is advisable to have coarse mesh nets, readily made on board from small stuff, stopped along the rail between the davits, and deep enough when dropped to reach down to the boat on the high roll of the ship. The boat's crew and passengers can come up or go down such a net more quickly and with greater safety than they can make their way up or down sea ladders. Such a net is particularly useful when hooking on a boat in a bad sea, when, of course, it is most desirable to lighten the boat of her crew as soon as possible.

Taking a Disabled Vessel in Tow at Sea. The Coast Guard practice in picking up a tow at sea is usually to get a line to the tow by heaving line or by the use of a shoulder gun. The cutter is placed in the most advantageous position in accordance with the principles laid down in Chapter XVI. In good weather it is generally unnecessary to use a boat and in bad weather it is seldom practicable.

When other conditions permit, it will generally be found handier in the case of a vessel having a single right-hand propeller to work under the starboard bow of a vessel for the reason that backing shapes up your own ship for going clear; whereas while under the port bow, backing shapes up your ship for fouling. It is always well to keep fifteen or twenty fathoms of your end of the hawser on deck. By so doing it will often be possible to ease the strain on a hawser, and still maintain good speed, by slacking away several fathoms and bringing the vessels in step. Whenever it is necessary to slack or veer a hawser, always stop your ship; if you do not take this precaution the hawser is liable to take charge of things. *Never make a hawser fast so that it cannot be let go or cut away instantly.* This precaution is often overlooked, particularly when towing with wire.

A hawser should be protected from chafe as much as possible. This applies to wire as well as to manila. With a vessel in tow, always slow down when about to make a pronounced change in course to avoid parting the line when the catenary snaps out of water and brings a sudden strain on the towing gear.

In picking up a sailing vessel underway, remember that she

is making good a course several points to leeward of her heading.

When heaving in a hawser that has parted or been let go, keep way on your ship, heading up to windward if practicable, to avoid fouling the propeller. *Whenever you have a line of any kind over your stern, keep constantly in mind the possible danger of fouling the propeller.*

A ship with disabled steering gear can sometimes be best handled by making fast astern of her. The disabled vessel can then do the towing and the assisting ship can do the steering by sheering across the former's stern as necessary.

A ship which yaws badly under tow on account of being down by the head may often be towed comfortably stern first. A drag over the stern of a ship being towed and yawing badly will generally relieve the yawing.

A change in speed or in course or both will often relieve dangerous strain on a towing hawser.

Floating a Stranded Vessel. This subject is discussed in Chapter XIX. The assisting vessel should feel her way in carefully, taking into consideration the stage of the tide and state of the sea. Remember that on a sandy beach a bar will often form outside of a large stranded ship. Every effort should be made to anchor in just the right position to pull most effectively, having in mind the way the current will probably set while lines are being run and while hauling on the stranded vessel.

The best time to pull is, of course, at high water. If you begin to pull a few minutes before high water and continue to pull with full power until twenty or thirty minutes after high water—in a locality where there is considerable rise and fall of the tide—without results, it is almost useless to continue to pull on the vessel; it is better to wait until the next high water.

With a line leading from a forward chock, use a "dipping rope" or bridle to keep the line away from your propeller.

It will be of very great assistance if, while pulling on the stranded vessel, another vessel is at hand to hold up the head of your ship against the set of the current. You will thus be enabled to pull along the direction best calculated to obtain the desired result.

When conditions permit, "jumping" on the line by getting a little slack on the hawser and then going ahead full speed will

sometimes start a stranded ship. This, however, always involves danger of parting the hawser or of doing other damage.

At night, it is a good idea for the stranded vessel to use a search light kept trained along her own keel line so that the assisting vessel will know at all times just how she is lying.

When a *small* vessel is ashore on a sandy beach and the sand has formed around her, a length of 2-inch pipe screwed on to a deck hose may be useful. Pumping water through the pipe may force away the sand sufficiently to enable the vessel to be floated. This has been successfully accomplished.

The Removal of Derelicts. To locate a derelict that has been reported by a passing steamer is often no easy matter. The success of the search depends upon a number of elements,—the accuracy of the original report, the time elapsed since the derelict was seen, the weather and currents. With such information as he has received, the Commanding Officer of a vessel ordered to find the derelict must use his best judgment in estimating the probable drift of the derelict since it was last reported. A systematic search should be planned and carried out in accordance with accepted methods (search curves) designed to cover to the best advantage, during daylight, the area in which the derelict may be expected to be found, giving due weight to conditions of weather and sea. In actual practice, it is rarely that a derelict is found without a protracted search.

The derelict when found should either be destroyed or taken in tow. The wrecking mines used for destroying derelicts are of the standard Navy type. The number of mines used and the manner of connecting them up will depend upon circumstances.

In order to get the best results, the mines should be *in actual contact* with the objects to be destroyed; this is often a difficult task and is sometimes impossible. To blow up a hull, particularly if it is waterlogged, the best method is to place the mines inside so that the explosive effect will rend the parts asunder. Or they may be placed under the hull, being held in place by hogging lines. The efficient use of wrecking mines to destroy derelicts and wreckage at sea calls for good judgment, considerable ingenuity and some former experience in the work, and is not devoid of danger.

To take a derelict in tow is apt to prove a slow and arduous task. It will often be difficult to find a suitable means of making

fast a towing hawser on the derelict; as, for example, on a hull floating bottom up. No two cases will be found exactly alike, and an officer must depend largely upon his resourcefulness and ingenuity to solve the problem presented.

Coast Guard Stations.

The sea and lake coasts of the United States, exclusive of the coast of Alaska, have an extent of more than 10,000 miles. There are to-day upon these coasts 273 active Coast Guard stations, 180 of which are on the shores of the Atlantic, 9 on the shores of the Gulf of Mexico, 21 on the shores of the Pacific, and 62 on the shores of the Great Lakes. These stations are located at selected points of danger to shipping and vary somewhat in character, according to their environment and the nature of the service demanded of them. On some portions of the coast they are placed only at long intervals, while upon others they form chains of contiguous posts within communicating distance of each other.

The **equipment** of Coast Guard stations consists of the beach apparatus—line-projecting guns, hawsers, breeches buoys, etc.—flag and pyrotechnic signals, heaving sticks and lines, life preservers, life cars, and life boats, surf boats, and other types of boats.

The outfits are practically the same at all the stations, but the boats are of various types, depending upon their suitability for rescue work on the different coasts. The life boats are too heavy to be launched from the beach into the surf, and launching ways are provided and located for them where comparatively smooth water prevails—on rivers, bays, and inlets. The surf boats are launched into the surf without the aid of launching ways.

Types of Boats.—Boats used in the Coast Guard may be divided into two general classes—those driven by gasoline motors and those without motive power other than sails or oars. They are further subdivided as to their hull construction into three classes: open boats, self-bailing boats, and self-righting and self-bailing boats.

Line-carrying Guns, etc.—For effecting line communication with stranded vessels and between cutters and disabled vessels

in heavy weather the Coast Guard chiefly employs the Lyle gun, but other types may of course be used.

For a vehicle in which to transport people from a wreck to shore after line communication has been established, the breeches buoy is generally used. The life car is sometimes taken, however, especially where many persons are to be landed and where the distance is too great to use the breeches buoy. The car is a covered boat, made of corrugated galvanized iron, furnished with rings at each end, into which hauling lines are bent, whereby the car is hauled back and forth on the water between the wreck and the shore without the use of any apparatus. It is supplied, however, with bails, one near each end, by which it can be suspended from a hawser and passed along upon it like the breeches buoy if found necessary, as is sometimes the case where the shore is abrupt. The cover of the boat is convex, and is provided with a hatch, which fastens either inside or outside, through which entrance and exit are effected. Near each end it is perforated with a group of small holes, like the holes in a grater, punched outward, to supply air for breathing, without admitting much, if any, water. It is capable of containing six or seven persons, and is very useful in landing sick people and valuables, as they are protected from getting wet. On the first occasion of its use it saved 201 persons. (Plate **183.**)

At Coast Guard stations a fixed beat or patrol is laid out in each direction along the shore, varying, according to the conformation of the coast with respect to inlets, headlands, etc. from one-half to 2, 3, or 4 miles in length. The station crew is divided into regular watches of two men each, who during the hours from sunset to sunrise, patrol these beats, keeping a sharp lookout seaward at all times.

At sunset the first man starts out on patrol in the same direction from all stations in a district, so far as practicable. While the patrolman is out, his watchmate takes the station watch, which is kept in the tower or on the beach abreast the station, as conditions may require. If the station is connected with the service telephone line, the station watch makes it his business to be within hearing distance of the bell at regular intervals. In addition to keeping watch seaward, he is on the lookout for signals and telephone calls from the patrolman. Upon the return of the first patrol, he takes the station watch and the other man

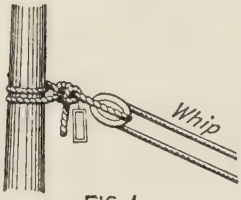


FIG. 1
TAIL-BLOCK HAULED OFF BY FIRST LINE FROM SHORE

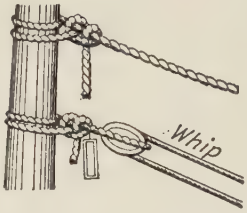


FIG. 2
HAWSER HAULED OFF BY WHIP

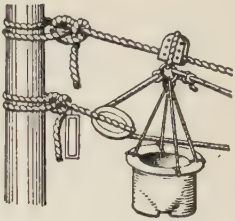


FIG. 3
BREECHES BUOY.

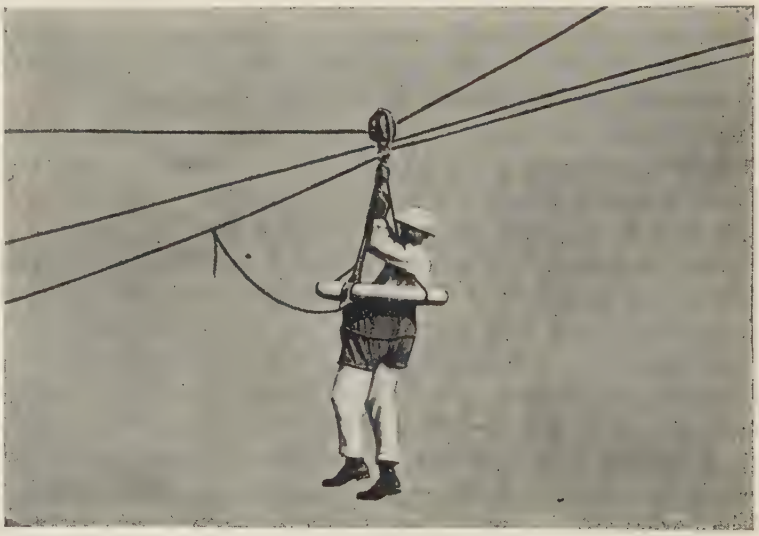


Fig. 4. Breeches Buoy in Use.

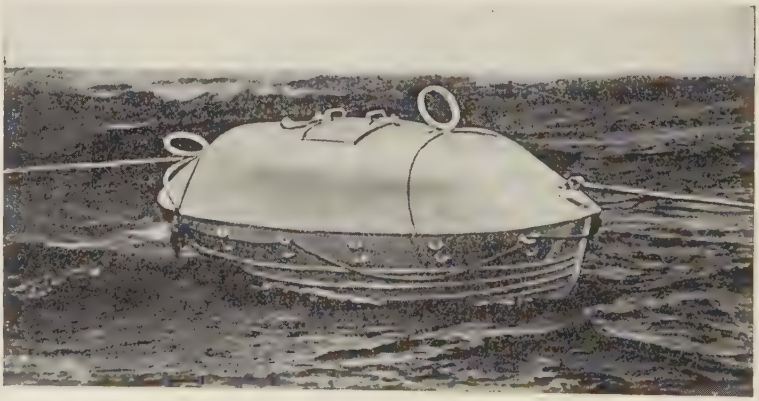


Fig. 5. Life Car as Used in Drill.

RESCUING PASSENGERS FROM STRANDED VESSEL.

patrols in the opposite direction. At the proper time the man on station watch calls out the next two men, who must be dressed and ready for duty before the first two turn in.

This routine is varied to meet local conditions. In harbors and seaports fixed lookouts are usually maintained instead of a beach patrol.

In some cases telephones are located in halfway houses or at the ends of the patrols; in such cases the patrolmen report to their stations by telephone. In other cases the patrolman is provided with a small hand telephone set with which he can communicate with the station.

Each patrolman carries a number of red Coston signals with which to warn a vessel standing too close inshore or to notify a vessel in distress that he has gone to summon assistance.

The same system of patrols is kept up in thick and foggy weather.

It should be stated that the beach patrol is an institution of distinctly American origin. It was devised by the former Life-Saving Service and inaugurated in that service about 1870-75.

To insure that the crews of wrecked vessels shall understand what to do when station crews are making rescues by means of the beach apparatus gear, two tally boards or tablets are used. One of these is spliced permanently into the tail of the whip block just above the splice, and the other is spliced or bent on the top end of the hawser. Each tally board contains inscriptions, in English on one side and in French on the other, telling explicitly what is to be done after they are received.

Instructions to Mariners in Case of Shipwreck.

All sea-faring people should be familiar with the following instructions, which are practically identical with those issued by all nations having Life Saving Services. It is the unanimous testimony of the personnel of such services that the principal difficulties with which they have to deal arise from the failure of shipwrecked crews to cooperate intelligently in the work of rescue.

Instructions.

Rescue with the Life Boat or Surf Boat.

The patrolman, after discovering your vessel ashore and burning a Coston signal, hastens to his station for assistance. If the use of a boat is practicable, either the large life boat is launched from its ways in the station and proceeds to the wreck by water, or the lighter surf boat is hauled overland to a point opposite the wreck and launched, as circumstances may require.

Upon the boat reaching your vessel, the directions and orders of the Warrant Officer in charge (who always commands and steers the boat) should be implicitly obeyed. Any headlong rushing and crowding should be prevented, and the captain of the vessel should remain on board, to preserve order, until every other person has left.

Women, children, helpless persons, and passengers should be passed into the boat first.

Goods or baggage will positively not be taken into the boat until all are landed. If any be passed in against the warrant officer's remonstrance he is fully authorized to throw the same overboard.

Rescue with the Breeches-Buoy or Life-Car. (Plate **183.**)

Should it be inexpedient to use either the life boat or surf boat, recourse will be had to the wreck-gun and beach apparatus for the rescue by the breeches-buoy or the life-car.

A shot with a small line attached will be fired across your vessel.

Get hold of the line as soon as possible and haul on board until you get a tail-block with a whip or endless line rove through it. This tail-block should be hauled on board as quickly as possible to prevent the whip drifting off with the set or fouling with wreckage, etc. Therefore, if you have been driven into the rigging, where but one or two men can work to advantage, cut the shot-line and run it through some available block, such as the throat or peak-halliards block, or any block which will afford a clear lead, or even between the ratlines, that as many as possible may assist in hauling.

Attached to the tail-block will be a tally-board with the following directions in English on one side and French on the other:

"Make the tail of the block fast to the lower mast, well up. If the masts are gone, then to the best place you can find. Cast off shot-line, see that the rope in the block runs free, and show signal to the shore."

The above instructions being complied with, the result will be as shown in Fig. 1, Plate **183.**

As soon as your signal is seen a three-inch hawser will be bent on to the whip and hauled off to your ship by the life-saving crew.

If circumstances will permit, you can assist the life-saving crew by manning that part of the whip to which the hawser is bent and hauling with them.

When the end of the hawser is got on board a tally-board will be found attached, bearing the following directions in English on one side and French on the other:

"Make this hawser fast about two feet above the tail-block, see all clear and that the rope in the block runs free, and show signal to the shore."

These instructions being obeyed, the result will be as shown in Fig. 2, Plate **183.**

Take particular care that there are no turns of the whip-line round the hawser. To prevent this take the end of the hawser UP BETWEEN *the parts of the whip before making it fast.*

When the hawser is made fast, the whip cast off from the hawser, and your signal seen by the life-saving crew, they will haul the hawser taut and by means of the whip will haul off to your ship a breeches-buoy suspended from a traveler-block, or a life-car from rings, running on the hawser.

Fig. 3, Plate **183**, represents the apparatus rigged, with the breeches-buoy hauled off to the ship.

If the breeches-buoy be sent, let one man immediately get into it, thrusting his legs through the breeches. If the life-car, remove the hatch, place as many persons into it as it will hold (four to six), and secure the hatch on the outside by the hatch-bar and hook, signal as before, and the buoy or car will be hauled ashore. This will be repeated until all are landed. On the last trip of the life-car the hatch must be secured by the inside hatch-bar.

In many instances two men can be landed in the breeches-buoy at the same time by each putting a leg through a leg of the breeches and holding on to the lifts of the buoy.

Children, when brought ashore by the buoy, should be in the arms of older persons or securely lashed to the buoy. Women and children should be landed first.

In signaling as directed in the foregoing instructions, if in the daytime, let one man separate himself from the rest and swing his hat, a handkerchief, or his hand; if at night, the showing of a light, and concealing it once or twice, will be understood; and like signals will be made from the shore.

Circumstances may arise, owing to the strength of the current or set, or the danger of the wreck breaking up immediately, when it would be impossible to send off the hawser. In such a case a breeches-buoy or life-car will be hauled off instead by the whip, or sent off to you by the shot-line, and you will be hauled ashore through the surf.

If your vessel is stranded during the night and discovered by the patrolman, which you will know by his burning a brilliant red light, keep a bright lookout for signs of the arrival of the life-saving crew abreast of your vessel.

From one to four hours may intervene between the burning of the light and their arrival, as the patrolman will have to return to his station, perhaps three or four miles distant, and the life-saving crew draw the apparatus or surf boat through the sand or over bad roads to where your vessel is stranded.

Lights on the beach will indicate their arrival, and the sound of cannon-firing from the shore may be taken as evidence that a line has been fired across your vessel. Therefore, upon hearing the cannon, make strict search aloft, fore and aft, for the shot-line, for it is almost certain to be there. Though the movements of the life-saving crew may not be perceptible to you, owing to the darkness, your ship will be a good mark for the men experienced in the use of the wreck-gun, and the first shot seldom fails.

Recapitulation.

Remain by the wreck until assistance arrives from the shore, unless your vessel shows signs of immediately breaking up.

If not discovered immediately by the patrol, burn rockets,

flare-up, or other lights, or, if the weather be foggy, fire guns.

Take particular care that there are no turns of the whip-line round the hawser before making the hawser fast.

Send the women, children, helpless persons, and passengers ashore first.

Make yourself thoroughly familiar with these instructions, and remember that on your coolness and strict attention to them will greatly depend the chances of success in bringing you and your people safely to land.

The following signals, approved by the International Marine Conference convened at Washington in October, 1889, have been adopted by the United States Coast Guard, and will be used and recognized by the officers and men as occasion may require:

"Upon the discovery of a wreck by night, the life-saving force will burn a red pyrotechnic light or a red rocket to signify—'You are seen; assistance will be given as soon as possible.'

"A red flag waved on shore by day, or a red light, red rocket, or red Roman candle displayed by night will signify—'Haul away.'

"A white flag waved on shore by day, or a white light slowly swung back and forth, or a white rocket, or white Roman candle fired by night will signify—'Slack away.'

"Two flags, a white and a red, waved at the same time on shore by day, or two lights, a white and a red, slowly swung at the same time, or a blue pyrotechnic light burned by night, will signify—'Do not attempt to land in your own boats. It is impossible.'

"A man on shore beckoning by day, or two torches burning near together by night, will signify—'This is the best place to land.'

"Any of these signals may be answered from the vessel as follows: In the daytime, by waving a flag, a handkerchief, a hat, or even the hand; at night, by firing a rocket, a blue-light, or a gun, or by showing a light over the ship's gunwale for a short time, and then concealing it."

NOTE.—This chapter has not changed since originally written nearly 16 years ago, for the Eighth Edition. It is just as true today as when first written.

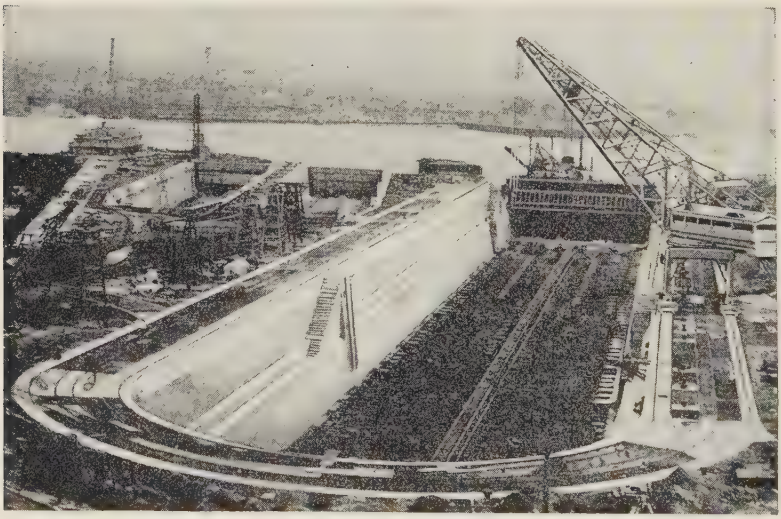
CHAPTER XXII

PLACING A SHIP IN DRY DOCK.

Definitions.

A **Dry Dock** (or graving dock) (Plate **184**) is a narrow basin, having walls and a floor, in which vessels may be placed and from which the water may be pumped out, leaving the vessel dry and supported on blocks. It is used in repairing and cleaning the

Plate No. 184



GRAVING DOCK.

under-water hull of a ship and in some cases in constructing ships.

A **Floating Dry Dock** (Plate **185**) is a rectangular shaped, open ended, sectional type, movable dock; capable of being submerged to take a ship's hull and of supporting the vessel when pumped dry. Used where there is no site available for an or-

dinary dry dock or where special conditions render the floating structure more convenient or economical. Usually self contained.

A **Marine Railway** (Plate 186) is an inclined shipway by means of which a vessel of moderate size, resting in a cradle on wheels, can be drawn out of the water above the reach of the tide. The cradle is moved by means of a windlass and endless chain. Used mainly for destroyers, submarines and small craft.

A **Caisson** is a hollow gate, floating or sliding, used to close off the dry dock after a vessel enters. In the floating type valves admit water to sink it and it is capable of self pumping for raising.

The **Sill** is raised above the floor at the entrance to a dry dock and supports the caisson when in place.

Keel Blocks are wooden blocks secured to the bottom of the dry dock on its center line to support a vessel's keel.

Docking Keel Blocks are wooden blocks upon which a vessel's docking keel rests.

Wale Shores are spars extending from the ship's side to the side of the dock to assist in keeping the ship upright.

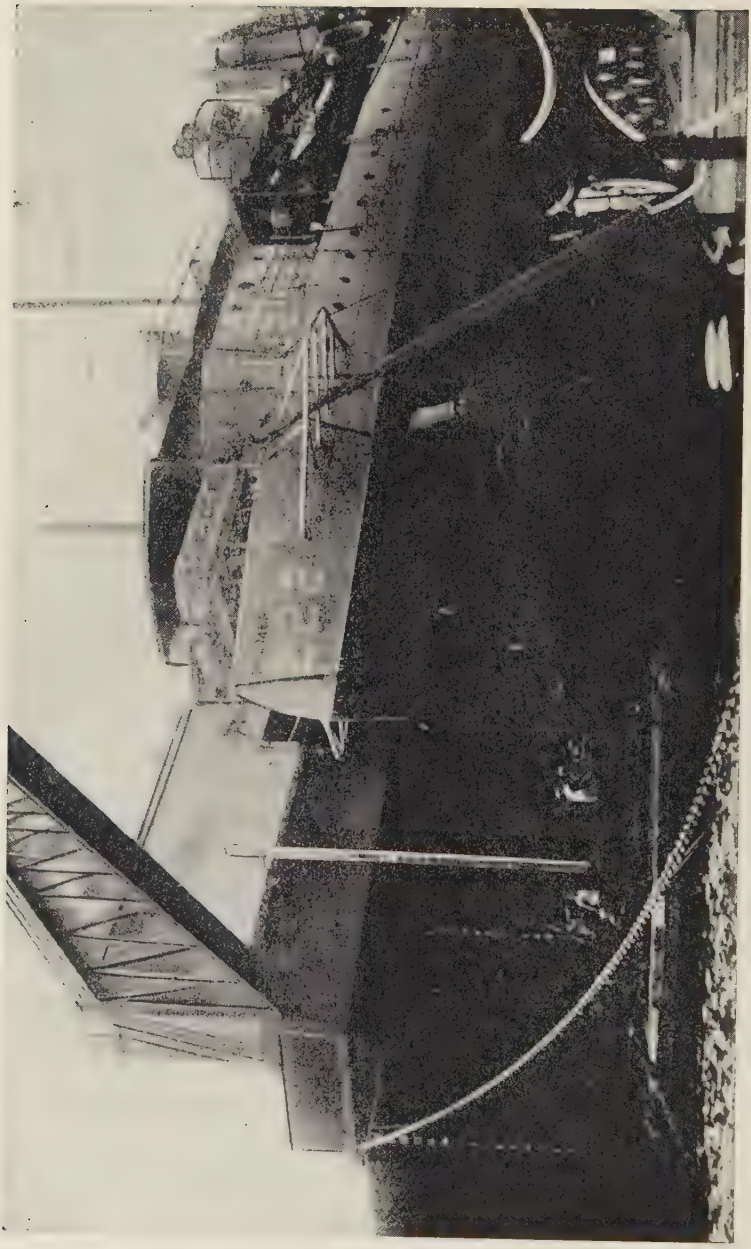
Docking Plan. Ship's plan, furnishing all necessary information for docking purposes concerning the under-water hull.

Preparations for Docking.

In preparing a dry dock to receive a vessel the dockmaster first refers to the ship's docking plan. For U. S. men-of-war a copy of this will usually be found in our Navy Yard files, but every ship should carry its own docking plan. To place blocks accurately, and to build them up to proper height and bevel, the docking plan should show the following information:

1. Full extent of keel with flat and rising portions accurately delineated.
2. Peculiarities of stern post and rudder.
3. Sections, amidship and elsewhere, to show proper height and bevel of bilge blocks, if these be necessary.
4. Shape and location of keels, docking keels, bilge keels, struts, propellers, under-water fittings, and projections of all kinds.

Further, since it is often necessary to provide more blocks than usual under heavy weights, the docking plan should show:



FLOATING DOCK.

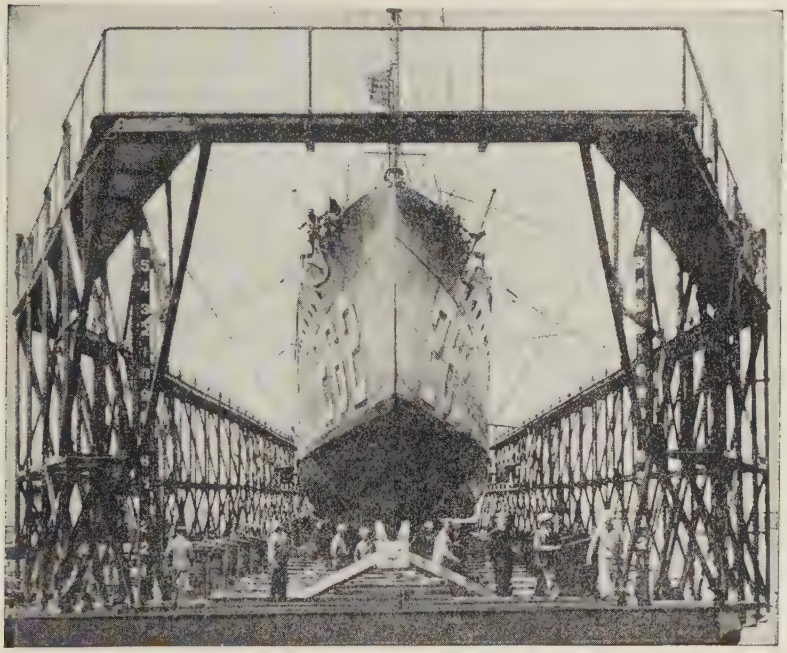
5. Location of turrets, boilers, engines and other unusual weights.

To assist in locating sighting battens the plan should show:

6. The length on the load water line.

Finally to enable the dockmaster to determine whether or not the dock can take a ship, or to place her accurately in the dock the plan must show:

Plate No. 186



MARINE RAILWAY.

7. The length overall, beam, and all projections increasing nominal beam such as blisters.

Broadly speaking, all that is now necessary to prepare the dock for the ship is to set up the keel and docking keel blocks to the proper height and in the proper position in the dock to receive the keel and docking keels of the ship. The ship is then floated into the dock over the blocks, the dry dock entrance closed by means treated below and the water in the dock pumped out. The ship will settle down and be supported by the blocks.

Some of our older cruisers, some destroyers and most merchantmen are not fitted with docking keels. Such a ship if placed in a dock with only keel blocks would, when the dock was partially dry or empty, have a tendency to topple over. In such cases the ship is supported in its upright position in our docks by wale shores, cut to proper length, from the ship's side to the side of the dock, and by bilge blocks, built up to proper height and bevel which are capable of being hauled on ways in the floor of the dock in a direction perpendicular to the keel line under and against the skin of the ship. The sequence of docking such a ship is to land her fore and aft, set up shores with wedges, finally, when the water in the dock has been pumped until the main weight of the ship is taken on the keel blocks, haul bilge blocks.

Submarines present still a third form of docking preparation since the center keel is flat but for a short distance, if any, and the keel blocks must be built up to various heights, as indicated by the docking plan, so that when landed the ship will be well supported all along the keel. Ordinary ships with the forefoot cut up considerably or a great overhang aft are often treated in the same manner although usually in this case there is enough flat keel to allow shoring of the overhangs after the dock is dry.

Blocks, of any kind, and shores must not come up against any fittings or other hull accessories, parts of the hull itself, or projections (such as rolling keels) which would be damaged by heavy local pressures. Hence, the height of sliding bilge blocks is carefully chosen to insure taking up in way of longitudinals, bulkheads or frames, and low enough to clear the rolling keels. It is often necessary to omit certain keel and bilge blocks to prevent taking up on underwater valve connections, oscillators, etc.

From the preceding paragraph it will be readily appreciated that, the fore and aft position of the blocks in the dock being fixed, it is highly important to fix also the fore and aft position of the ship in the dock to insure blocks landing in their proper positions. This is accomplished by placing marks on the coping of the dock opposite predetermined final positions of the ship, such as bow and stern at water line, and setting up sighting battens thereon. It is of course equally important to fix the position of the ship athwartship of the dock so that the keel will land on the keel blocks, and this is accomplished by bringing bow and

stern in line with plumb bobs suspended from chains over the center of the dock, or lining up masts, funnels, etc., with battens placed on the prolongation, at each end of the dock, of its centerline.

Docking.

The dockmaster of any particular dock being given the docking plan of a ship to be placed therein, proceeds as follows:

Knowing the ship's draft, the maximum depth over the sill, together with current and tidal variations in the vicinity, he decides upon the time the vessel should enter the dock, and so informs the commanding officer. The commanding officer thereupon makes the necessary arrangements to insure that the vessel at the time specified shall be absolutely upright, without any list to starboard or port, and with as nearly zero trim as possible.

The dock being prepared, water is admitted, the caisson is floated and removed, and the ship is brought to the dock entrance. After the ship's bow has safely entered the mouth of the dock, the responsibility for her safety rests upon the dockmaster, who thereupon hauls her into the dock, replaces and sinks the caisson, starts the dock pumps, centers the ship and proceeds with the docking as outlined above.

The particular precautions which must be taken in docking ships which are not in ordinary conditions, must depend upon the judgment of the dock master.

During the period that a ship is in dock, no change of any kind in the distribution of her weights should be made without the knowledge and consent of the dockmaster, because the ship when being floated might suddenly change her trim so as to cause serious damage to herself or to the dock.

Work on Ships in Dock.

After the dock is dry the following routine dry dock work is proceeded with:

1. Clean bottom, including scaling or wire-brushing of badly corroded plates.
2. Cut out and redrive all loose or badly corroded rivets.
3. Caulk leaky seams and rivets.
4. Overhaul underwater valves.

5. Repack underwater stuffing boxes.

6. Renew zinc and mild steel protectors as necessary.

7. Take propeller shaft clearances, re-wooding stern and strut bearings if necessary.

8. Check pitch of propellers.

9. Examine rudder pintles and gudgeons.

10. Paint bottom with Anti-corrosive paint, paint draft marks, paint between light and load water lines with boot-topping.

11. Paint bottom with Anti-fouling paint.

If special repairs have been anticipated or are found to be necessary after the dock is empty, the necessary action is taken immediately, because the length of time a ship remains in dock must be reduced to the minimum to avoid unnecessary expense.

Undocking.

After the bottom is painted and all under-water repairs completed, a time for flooding the dock is agreed upon by the commanding officer and the dock master. The former stations men at the outboard valves and elsewhere, as he deems proper, to insure that water does not enter the ship. The dockmaster stations men at the various shores and lines and elsewhere, to prevent as far as possible, any injury to dock or ship, from a change of weights or an unexpected alteration in tide or wind.

The water in the dock enters continuously under the dockmaster's control. When it has risen to a sufficient height, the bow ordinarily first lifts from the keel blocks, and shortly afterwards the stern. If there has been any material change of weights while the ship has been in dock, she will suddenly and violently take a list to starboard or to port, with consequent damage to herself and the dock. When the ship is safely afloat, the water is allowed free entrance until the level within the dock coincides with that outside. The caisson is floated as quickly as possible, then removed, and the ship is floated out of the dock.

Floating Dry Docks.

The latest development in drydock construction is in the direction of mobile floating docks. These structures are being built entirely in one piece and with the usual ship bow. They are

equipped with steering mechanism and a stern gate, which can be raised and lowered. They are self contained in that they are provided with facilities for the storage and distribution of water, air, fuel oil, etc. The U. S. Navy has planned such a dock of sufficient size to accommodate all existing U. S. Naval vessels.

APPENDIX.

§ 1. SAILING SHIPS.

Although sails and spars have practically disappeared from the navy and from the experience of the average seafaring man even in the merchant service, they are far from having disappeared from the ocean; and some familiarity with them may still be expected on the part of every seaman who aspires to be even tolerably well informed in his profession.

Plates **187, 188, 189,** and **193** show the various rigs which are commonly seen in deep-sea vessels.

A **ship,** often referred to as "a full-rigged ship," has three masts; the fore, main, and mizzen, all of them square-rigged.

A ship may have more than three masts. Four-masted ships are common, and five-masters are occasionally seen. In a four-master the after-mast is called the jigger-mast. In a five-master, the masts are usually called "fore," "main," "middle," "mizzen," and "jigger."

A **Barque** has three masts, the fore and main square-rigged, the mizzen, fore-and-aft rigged.

A barque, like a ship, may have more than three masts, the names being the same as in the case of a ship. She is still a barque if all the masts except the after one are square-rigged.

A **Barkentine** has three or more masts, of which the two after ones, main, and mizzen, or mizzen and jigger, are fore-and-aft rigged. A five-master, with the three after-masts fore-and-aft rigged is still a barkentine.

A **Brig** has two masts, both full square-rigged. A brigantine is a brig without a square mainsail; that is to say, she carries all the square sails of a brig on both fore and main masts, except the mainsail.

A **Hermaphrodite Brig** has two masts, the foremast full square-rigged, the mainmast full fore-and-aft rigged. A hermaphrodite brig is often incorrectly called a brigantine.

A **Topsail Schooner** has a fore-and-aft foresail, with a square fore-topsail, and in some cases a fore-topgallant sail. The main-

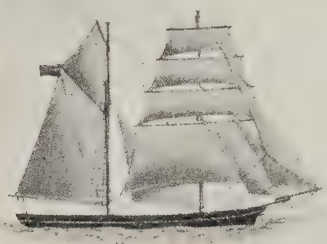
mast is full fore-and-aft rigged. A topsail schooner is often incorrectly called a hermaphrodite brig.

A **Schooner** has two, three, or more masts, all fore-and-aft rigged. The designations of the masts where there are more than two are the same as in the case of a ship or a barque.

There are many variations in the single-masted rig shown in the **Cutter** of Plate **187.** The "sloop" differs from the cutter so far as rig is concerned in having a short fixed bowsprit instead of a long movable one, and in carrying only one head sail. The most important distinction, however, between the sloop and the cutter, as at present recognized by yachtsmen, has to do with the model of the hull rather than with the rig.

The **Ketch** and the **Yawl** are modifications of the single-master rather than of the schooner, since they have grown out of the desire to make the total sail area more manageable by dividing it. For racing, the "single-sticker" holds its own because, as is well known, a given amount of canvas has far greater *driving* power in one sail than in two. An incidental advantage of the yawl or ketch rig is that the craft can be handled under very small sail—jib and jigger—which is a great convenience in working around a harbor, and may be of vital consequence in bad weather when the mainsail must be lowered, perhaps only for reefing; a situation in which the boat under a jib alone would be altogether unmanageable, and reefing a difficult and dangerous operation.

The same considerations of manageability with a small crew which have led to the development of the yawl and ketch from the single-master, have led to the division of the mainsail of large schooners, resulting in the production of schooners of three, four, and more masts.



HERMAPHRODITE BRIG.

TOPSAIL SCHOONER.

SCHOONER
may have as many as five masts

KETCH.
YAWL, same as KETCH but with a smaller mizzen abaft the tiller.

CUTTER.

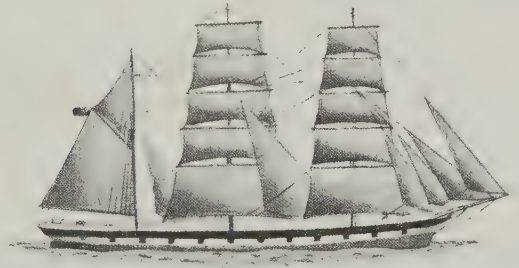
LUGGER.

SAILING CRAFT.

FULL RIGGED SHIP.

BARQUENTINE.

BRIG.
BRIGANTINE same as BRIG., but without a square mainsail.



BARQUE.

SAILING CRAFT.

Details of Rigging—Square-Riggers.

Masts. Lower masts in modern ships are usually built up of steel plates stiffened in various ways by steel shapes.

Built-up masts of wood are no longer used, although lower masts made of single pine sticks are not uncommon in sailing ships of moderate size.

Topmasts and topgallant-masts are still made of wood, usually of pine.

The mast rests on a step, placed as low as possible; usually on the keelson. At the lower end is a *tenon* fitting into a *mortise* at the step. Where the mast passes through the successive decks, timbers are built in from beam to beam, forming *partners;* the space between these and the mast being filled by tightly fitting wedges.

The masthead is smaller than the body of the mast, and at the shoulder, called the *hounds,* where the reduction in size is made, heavy knees or *bibbs* are bolted on, widening the shoulder and forming a secure support for the *trestle-trees;* stout fore-and-aft pieces which, in their turn, support the *cross-trees,* the *top,* the *topmast,* and the eyes of the lower rigging. The cross-trees are athwartship pieces crossing the trestle-trees forward and abaft the masthead, and forming the principal part of the framing of the top. They are jogged down into the trestle-trees, and with the latter form a skeleton to which the comparatively light planking of the top is secured.

The lower masthead terminates in a square tenon, to which the *cap* is fitted. This may be of wood, iron-bound, or built up of steel.

The topmast passes through a round hole in the forward part of the cap, which thus binds the two masts together. In the heel of the mast is a thwartship hole, square in section, through which is placed an iron *fid,* with its ends projecting and resting on the trestle-trees on either side. Two sheaves placed diagonally in the heel of the topmast furnish a lead for the two pendants, by which the mast is sent up and down. The over-lapping parts of the lower masts and topmasts are the *doublings.*

The topmast head is fitted in practically the same way as the

lower masthead, and the heel of the topgallant-mast "doubles" upon it similarly. Cross-trees are used here as spreaders for the topgallant rigging, but without a top.

Topgallant and royal masts are in one, but the diameter is reduced at the topgallant masthead forming *hounds,* upon which rests the topgallant *funnel;*—a composition cylinder, with two thwartships arms forming the *"Jack."* At the royal masthead is a similar shoulder, with an iron band for the rigging, and above this is the *pole* terminating in a tenon to which the *truck* is fitted. The truck usually carries the point of a lightning conductor, the lower end of which makes contact with the hull, or, in the case of a wooden ship, with the copper well below the water-line.

Trysail masts are fitted up and down abaft the lower masts being stepped on deck and secured at the head by bands connecting by a key to corresponding bands on the lower mast.

Modern men-of-war rarely carry sail, and such masts as they have are usually for military purposes only;—in some cases for carrying light guns in elevated positions, in other cases merely for signalling.

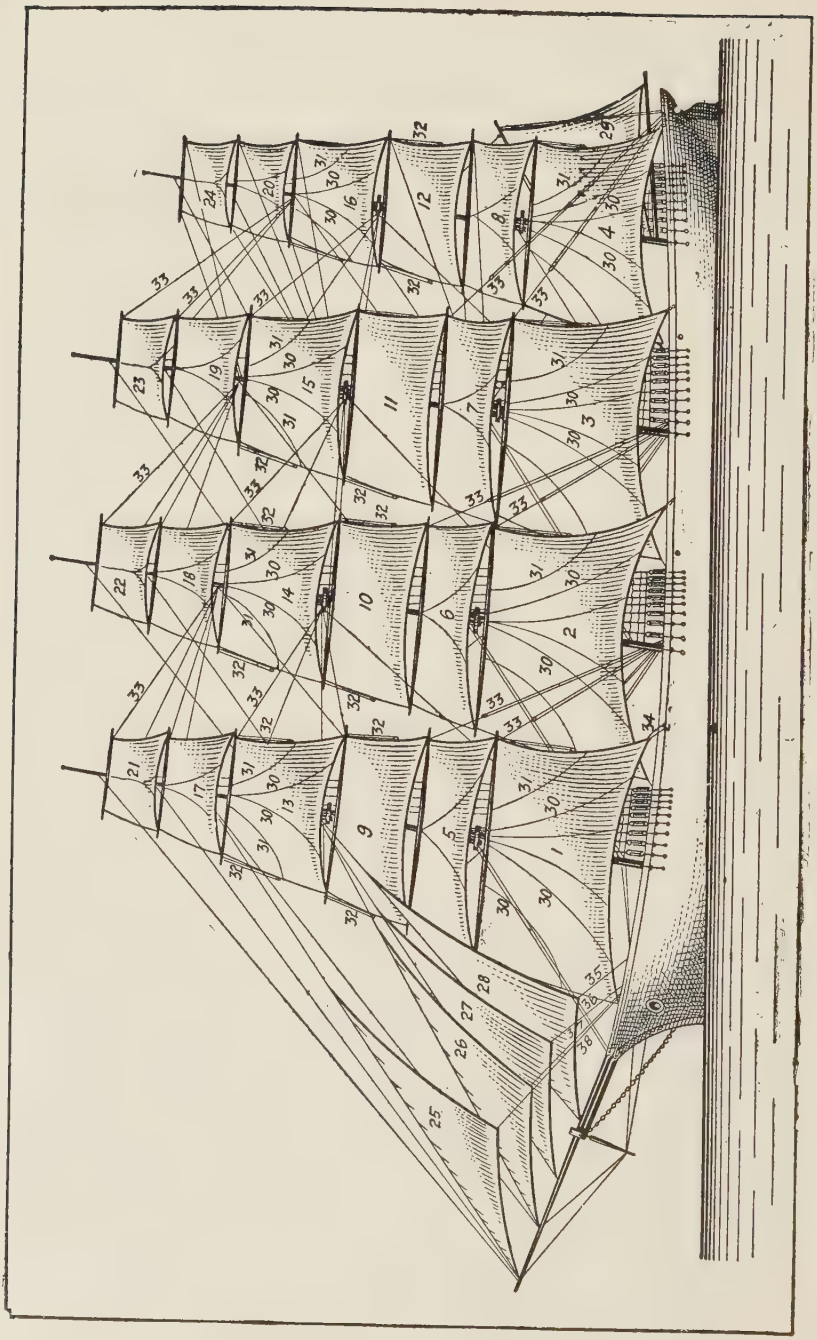
Yards. A full-rigged ship carries a lower, topsail, topgallant, royal, and sometimes a skysail, yard, on each mast. The topsail is usually double (Plates **189, 190**).

Standing Rigging. The masts of a ship are supported from the sides by *shrouds,* from forward by *stays* and from aft by *backstays.* The *backstays* contribute also to the sidewise support since they are necessarily led to the sides of the ship. The *stays,* in addition to supporting the masts, serve to carry certain fore-and-aft sails known as *staysails.* For convenience in hooking tackles at the mastheads for various purposes, heavy *pendants* are provided, fitted with thimbles and links and hanging well clear of the other rigging. Small lines, called "ratlines," stretched from shroud to shroud, furnish the means of going aloft.

The head-booms are supported from beneath, against the pull of the stays and the lifting tendency of the head sails, by *bobstays, martingales,* etc., leading to the cut-water; and from the sides by *bowsprit shrouds, jib-* and *flying jib-guys,* leading to the bow.

The above constitute the "Standing Rigging" of a ship.

Plate No. 189



FOUR-MASTED SHIP UNDER SAIL.

1 Foresail

2 Mainsail

3 Crossjack

4 Jigger

5 Lower fore topsail

6 Lower main topsail

7 Lower mizzen topsail

8 Lower jigger topsail

9 Upper fore topsail

10 Upper main topsail

11 Upper mizzen topsail

12 Upper jigger topsail

13 Fore topgallant sail

14 Main topgallant sail

15 Mizzen topgallant sail

16 Jigger topgallant sail

17, 18, 19, 20, Royals

21, 22, 23, 24, Skysails

25 Flying-jib

26 Outer-jib

27 Jib

28 Fore topmast staysail

29 Spanker

30 Buntlines

31 Leechlines

32 Reeftackles

33 Braces

34 Foresheet

35 Fore topmast staysail sheet

36 Jib-sheet

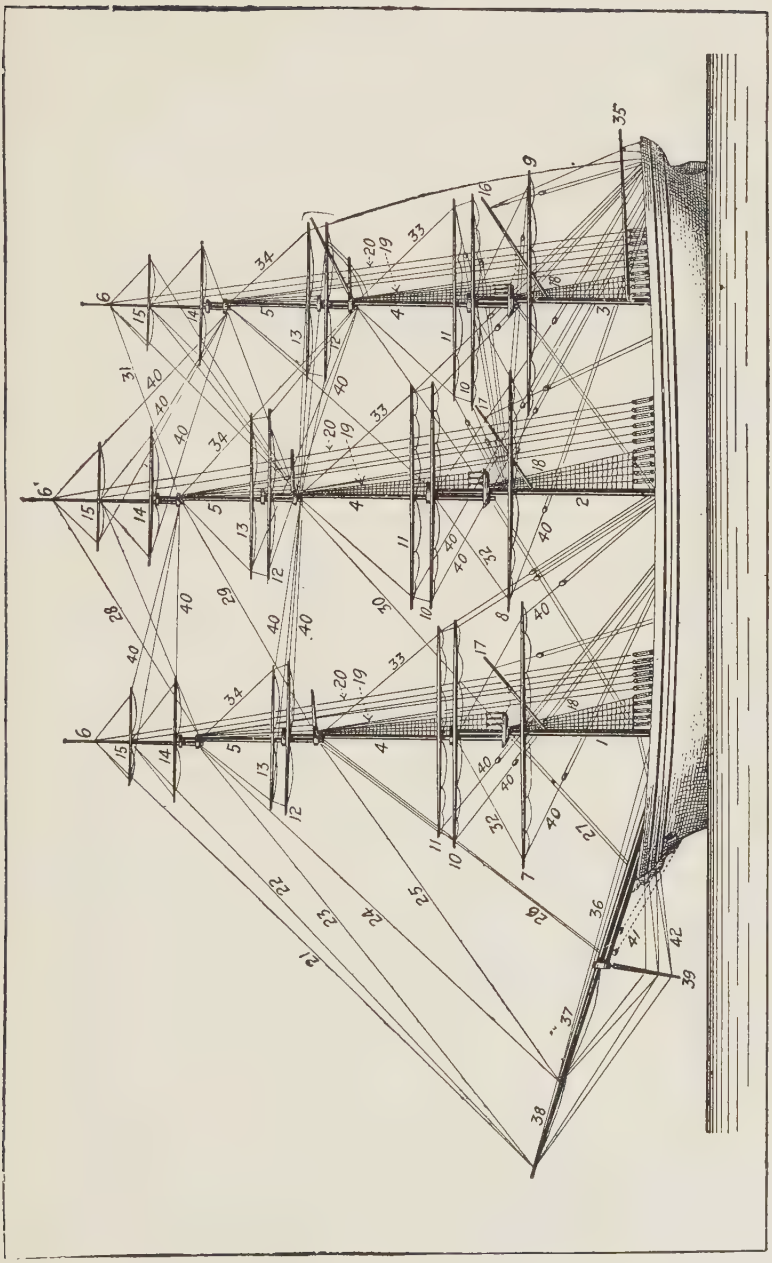
37 Outer jib-sheet

38 Flying jib-sheet

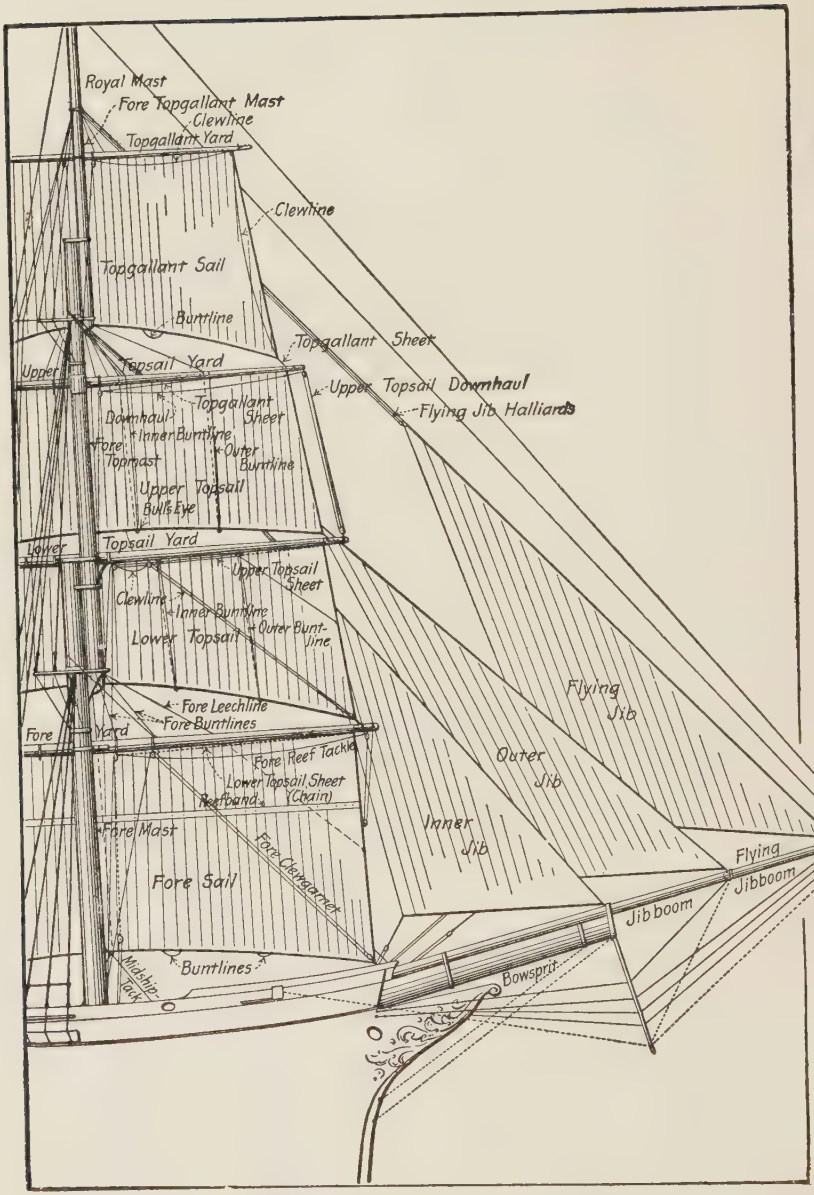
KEY TO PLATE 189.

1 Foremast
2 Mainmast
3 Mizzenmast
4 Topmasts; fore, main and mizzen.
5 Topgallant masts; fore, main and mizzen.
6 Royal and skysail masts; fore, main and mizzen.
7 Fore yard
8 Main yard
9 Crossjack yard
10 Lower topsail yards; fore, main and mizzen.
11 Upper topsail yards; fore, main and mizzen.
12 Lower topgallant yards; fore, main and mizzen.
13 Upper topgallant yards; fore, main and mizzen.
14 Royal yards; fore, main and mizzen.
15 Skysail yards; fore, main and mizzen.
16 Spanker gaff
17 Trysail gaff, fore and main
18 Lower shrouds
19 Topmast shrouds
20 Back stays
21 Fore skysail stay
22 Fore royal stay
23 Flying-jib stay
24 Fore topgallant stay
25 Jib stay
26 Fore topmast stays
27 Fore stays
28 Main skysail stay
29 Main topgallant stay
30 Main topmast stay
31 Mizzen skysail stay
32 Fore and main lifts
33 Topsail lifts
34 Topgallant lifts
35 Spanker boom
36 Bowsprit
37 Jib-boom
38 Flying jib-boom
39 Martingale or dolphin striker
40 Braces (named from yard to which they belong)
41 Bobstays
42 Martingale guys

KEY TO PLATE 190.



STANDING AND RUNNING RIGGING.



FORE MAST AND HEAD-BOOMS OF A MODERN SAILING SHIP, SAILS SET.

Standing Rigging is usually fitted of galvanized steel-wire rope, plain-laid, of six strands, and is protected from the weather, chafe and wear, by a thorough covering of worming, parcelling and serving (Plate **32**).

Sails. Sails are made of canvas, which may be of flax, hemp or cotton. The sails of ships are always of flax, those of boats and small yachts usually of cotton. Cotton canvas is used also on ship-board for a variety of purposes, such as awnings, windsails, hammocks, tarpaulins, etc.

Canvas is manufactured in long strips or *cloths,* varying in width from 16 to 24 inches for flax, and from 20 to 42 inches for cotton, and in lengths of from 40 to 80 yards. The cloths are made up in rolls called *bolts.*

Variations in weight, strength and fineness are indicated by numbers running from 1 to 10; number 1 being the heaviest, strongest and coarsest, and number 10 the lightest and finest.

Good canvas is made of long, strong, clean threads, evenly spun and well twisted and without any mixture of tow. In the heavier grades (Nos. 1 to 3), the threads are double, and in all grades the cloths should be closely and uniformly woven, and with a firm, even selvage. To test a sample of canvas, after examining carefully the character of the texture as to the smoothness and closeness of the weaving, it is well to bore through with a fid, when the threads will break easily if of inferior quality, and resist, with a disposition to stretch before yielding altogether, if of good strong staple. A few threads may be drawn and examined as to length, smoothness and freedom from tow; and finally, if two samples are to be compared, similar strips from the two may be knotted together and tested by hanging weights from them to determine which is the stronger.

An 80-yard bolt of No. 1 flax canvas, 20 inches wide, should weigh about 75 lbs. and the successive numbers from this to No. 10 should diminish by about 5 lbs. each, a bolt of No. 2 weighing 70 lbs., one of No. 3, 65 lbs., and so on.

The following numbers are commonly used for the sails of a full-powered sailing ship, the lighter grades specified in each case forming a fair-weather suit of sails, while the heavier ones are bent in anticipation of a stormy passage:

Courses,	Nos. 1 to 3.
Topsails,	" 2 to 3.
Topgallant sails,	" 4 to 5.
Royals,	" 5 to 6.
Topmast staysails,	" 3 to 4.
Jibs,	" 4 to 5.
Other staysails,	" 4 to 5.
Spankers, trysails, etc.,	" 4 to 5.
All storm sails,	No. 1

The square sails of a ship (Plates **188** and **189**) are the *courses* (foresail and mainsail), the *topsails, topgallant sails* and *royals.* A *skysail* is sometimes set above the royals. Topsails and topgallant sails may be single or double.

The fore-and-aft sails are the fore-and-main *trysails,* the *spanker* (which is in reality a mizzen trysail), the *staysails,* taking their names from the stays on which they are set, and the *jibs,* which are also staysails, although not socalled. The trysails are called also *spencers,* and the spanker is often called the *driver.*

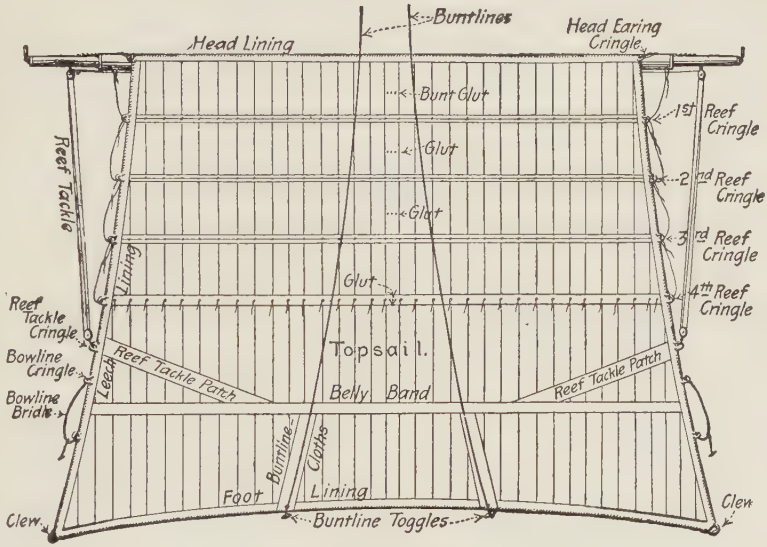
The upper edge of a square sail is called the *head,* the lower edge, the *foot,* the sides, *leeches,* the upper corners the *head cringles,* the lower corners, the *clews.*

In the case of a four-sided fore-and-aft sail like a trysail or spanker (Plate **192**) the after edge is the *after leech,* the forward edge the *luff,* the upper edge the *head,* the lower edge the *foot,* the upper after corner the *peak,* the upper forward corner the *nock,* the lower forward corner the *tack,* the lower after corner the *clew.*

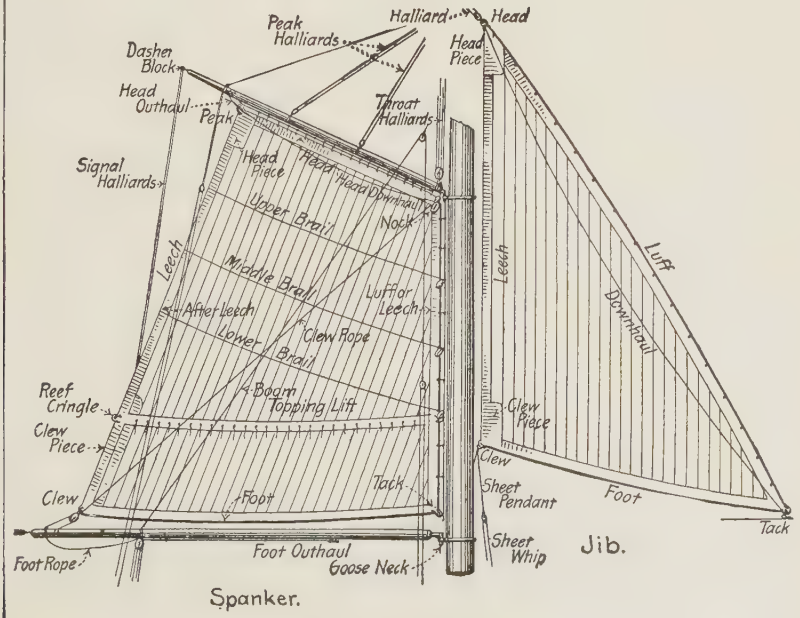
In a triangular sail (Plate **192**), the edge next the stay is the *luff,* the after edge the *leech,* the lower edge the *foot,* the lower forward corner the *tack,* the lower after corner, the *clew,* and the upper corner the *head.*

The details of sails of various kinds are fully shown in Plates **187, 188, 191** and **192.**

The cutting and making of sails constitute an art in themselves, which it would be beyond the province of this book to attempt to teach. The canvas must be cut with care, not only to economize material in adapting the narrow cloths to the irregular shapes required, but to reduce stretching to a minimum and to distribute such stretch as cannot be prevented, in a way to avoid distorting



Single Topsail.



DETAILS OF SAILS.

the sail and allowing it to bag. Canvas stretches very little along the line of the threads of either warp or filling, but may give considerably under a diagonal pull. Owing to the way in which sails are set (being hauled out by their corners), the greater part of the strain to which they are subjected is diagonal, and one of the most difficult points in sail making is to arrange the material in such a way that the cloths may take this strain directly along the threads. When this has been done as far as possible, allowance must be made for the stretch which still remains, and also for the difference in stretching between the canvas and the roping.

The cloths are sewed together with overlapping (double) seams having from 110 to 130 stitches to the yard. The twine used should be of good flax or cotton, spun with from three to eight threads and waxed with pure beeswax.

Sails are reinforced at points which are subject to especial strain or chafe.

The edges of the sail all around are turned over, forming a hem or *tabling* several inches wide. The linings and other strengthening pieces are then sewed on, and lastly the *bolt-rope*. This is of hemp and should be of the best quality, rather loosely laid up to make it soft and pliable, and tarred with the best Stockholm tar. As there is more stretch to the rope than to the canvas, care must be taken to leave a little slack canvas along the edges, as otherwise the canvas, instead of the roping, would take the strain when the sail is set. A common rule is to allow one inch of slack canvas for every foot along the leeches of topsails and canvas, and one inch for every yard along the foot.

The roping of square sails is always on the after side of the sails, that of fore-and-aft sails usually on the port side.

Double Topsails and Topgallant Sails. Modern sailing ships almost without exception have double topsail yards and in many cases double topgallant yards as well. This rig was first proposed by an American shipmaster named Howe, and its many advantages were promptly recognized (Plates **187, 188** and **191**).

In this rig, the lower topsail yard is fixed, while the upper yard hoists and lowers, the sail having half the depth of a single topsail. The lower (topsail) yard is trussed to the main cap, and the upper yard, when lowered, lies close above it. Thus by lowering the upper topsail, sail is reduced in a moment to the area

of an old-fashioned topsail when close-reefed, the upper topsail, when lowered, hanging forward of the lower topsail, where it is to a great extent becalmed.

Downhaul tackles are fitted from the yard-arms of the upper to those of the lower (topsail) yards to haul the yards down. This takes the place of "clewing-down" with a single topsail. The downhauls also support the lower topsail yard-arms, for which, usually, no lifts are fitted.

The lower topsail is fitted with sheets and clew-lines like an old-fashioned topsail, but as the leech is short, the clew-line blocks are placed well out on the yard. As a rule, the clews of the upper topsail shackle permanently to the lower topsail yard-arms.

Running Gear. The ropes, purchases, etc., by which the yards and sails are controlled constitute the Running Gear of the ship. Most of this gear is shown so clearly on the plates herewith, that a detailed description of their lead is unnecessary.

Halliards. Yards are hoisted by purchases consisting usually of a pendant, called a tye, and a purchase called the halliards.

The halliards of a staysail are bent to the head of the sail, lead up along the stay to a block at the masthead and thence on deck. For heavy sails, the halliards are double, and reeve through the blocks at the head of the sail, the standing part being made fast aloft and the hauling part leading as before.

The gaffs of trysails are supported by spans from the lower mast to the throat and peak, and when necessary may be hoisted and lowered by *throat* and *peak* halliards (Plate **192**).

Lifts. Yards are supported at the yard-arms by lifts, leading through blocks or fair-leaders at the masthead and thence to the top or the deck.

Braces. Yards are controlled as to their horizontal movement by *braces* leading from the yard-arms aft or forward. They are always led aft if circumstances permit this without requiring too much of a downward lead. In three-masted ships, the braces of yards on the fore-and-main are led aft, those of yards on the mizzen, forward.

Sheets. The clews of square sails are hauled out to the yards below them by sheets, reeving through sheaves in the yard-arms, thence through quarter-blocks under the yard and so to the deck.

Staysail and trysail sheets consist of pendants and whips, and

are usually double, each sail having its port and starboard sheet. In the case of a sail hauling out to a boom, the purchase for controlling the boom is the "sheet" and the sail is hauled out by an "outhaul."

Tacks. To control the clews of the *courses,* not only sheets, but *tacks,* are needed, the tack hauling the weather clew down and forward, the sheet hauling the lee clew down and aft. The forward lower corner of a fore-and-aft sail is called the "tack," as is also the rope by which this corner is held down and secured.

Clew-lines. In taking in the sails, the clews are hauled up to the quarters of the yard by clew-lines leading from the clews to the quarter-blocks and down on deck. For topsails and courses the clew-lines are double, and reeve through a block at the clew, the standing part being clinched around the quarters of the yard.

Clew-lines or clew-ropes are fitted to trysails for hauling the clew up to the jaws of the gaff, and on gaff topsails for hauling the clew up to the head.

Leech-lines are used to haul the leeches of courses and sometimes of topsails along the yard.

Buntlines. Buntlines haul the foot of the sail above and forward of the yard for convenience in furling. They are rove through blocks at the masthead or the top rim, lead down forward and toggle to the foot of the sail some distance outside the midship line on each side.

Reef-tackles. Reef-tackles are whips leading from the yard-arms of topsails and courses to cringle on the leeches of the sails, for hauling the leech up and out in reefing, affording slack for passing the earing and rousing the cringle up to its place.

Bowlines. Bowlines lead forward from the bowline bridles on the leeches of courses and topsails, and are used, when sailing on the wind, for hauling the leech well forward so that it shall hold the wind.

Outhauls. The head of a trysail is hauled out by a head outhaul, reeving through a sheave in the end of the gaff and a block at the mast, and then to the deck. The foot of a boom-sail is hauled out by a foot-outhaul reeving through a sheave in the boom.

Downhauls. Staysails are hauled down by downhauls leading from the head of the sail along the stay to a block at the tack of the sail.

The head of a trysail is hauled down by a head downhaul from the head of the sail to the jaws of the gaff.

Brails. Gaff sails—trysails, spankers, etc.—are gathered in to the mast for furling, by brails middled and stopped to the after leech, with a hauling part on each side reeving through a block on the mast at a point corresponding to the point at which they are stopped to the leech.

Vangs. Vangs are fitted to gaffs at the after end—one on each side—and led to the ship's side. Their office is to steady the gaff *when the sail is not set.*

Details of Rigging—Fore-and-Aft Rigs.

Plate **193** shows the sails and rigging of a two-masted schooner. There are many variations from this rig, especially in yachting, where special sails are used in racing and to some extent in cruising, under favorable conditions of weather. The **gaff topsail** is often replaced by a **"club-topsail,"** having the head and foot stretched out by long light spars which admit of spreading a greatly increased area of canvas. In this case the halliards are bent to the "yard" on the head of the sail near the middle point, and the yard, when hoisted to the masthead, carries the peak of the sail well up, playing the part of a topmast "pole."

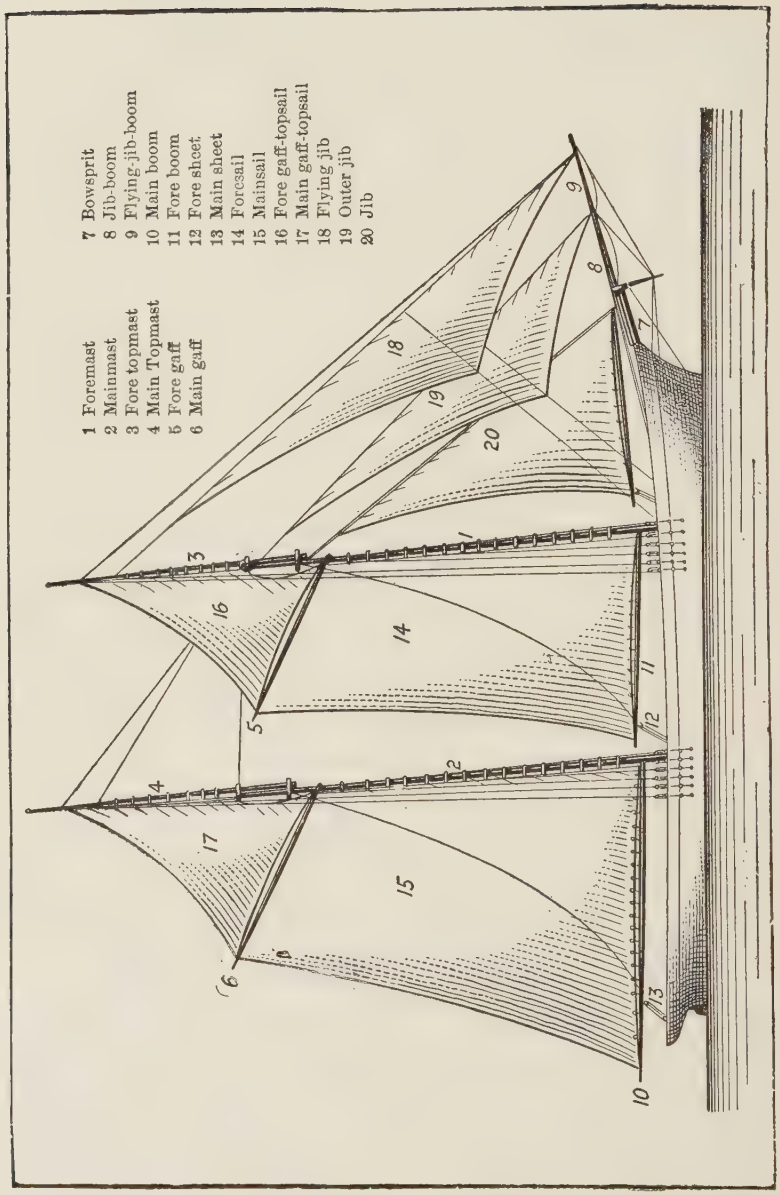
A **balloon-jib** is a very large triangular sail extending from the fore-topmast head to the jib-boom end. As it has no stay, it is set "flying."

A **jib-topsail** sets on the fore-topmast stay and corresponds to the flying-jib of an ordinary schooner.

A **spinnaker** is a very large, very light triangular balloon-like sail, often made of raw silk, used in running free. The head goes to the mast-head—either fore or main—and the foot hauls out to a **"spinnaker-boom,"** temporarily rigged out on the side opposite the main-boom.

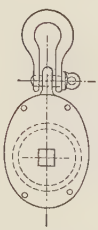
Where the spinnaker, instead of being triangular in shape, is quadrilateral, its head, always very short, hauls out on a temporary gaff rigged out for the masthead, the foot hauling out as in other cases to the spinnaker-boom. In this case the sail is called a **"shadow."**

Various other sails—of questionable utility—are set at times by racing yachts. Such are **"water sails"** under the spinnaker boom; **"ring-tails"** increasing the area of the mainsail, etc.



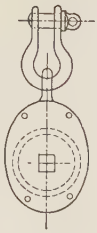
SCHOONER UNDER SAIL.

The ordinary main topmast staysail is often replaced by a very large sail of the same general type as the spinnaker and the balloon jib.



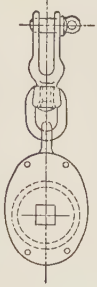
1

Shackle, Regular, Front; Loose



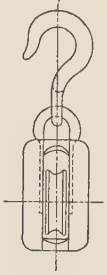
2

Shackle, Upset; Front; Loose



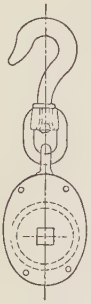
3

Shackle, Upset; Swivel Link, Loose



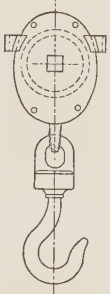
4

Hook, Single, Side; Loose



5

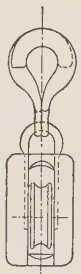
Hook, Single, Swivel Link; Loose



Lower Falls Block

6

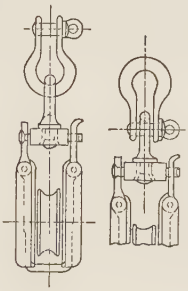
Hook, Single, Ball Bearing Swivel Link; Loose



To be Fitted only on "Blocks 6" and Below"

7

Hooks, Sister, Side; Loose



8

Shackle, Upset; or Regular; Swivel Eye; Loose

BLOCKS
Circ. of Manila Rope
RIGS

1- Shackle, Regular, Front; Loose.
2- Shackle, Upset, Front; Loose.
3- Shackle, Upset, Swivel Link; Loose.
4- Hook, Single, Side; Loose.
5- Hook, Single, Swivel Link; Loose.
6- Hook, Single; Ball Bearing Swivel Link; Loose.
7- Hooks, Sister; Side Loose.
8- Shackle, Upset, or Regular Swivel Eye; Loose.

GENERAL NOTES

1 - Size of Block Refers to Approximate Length of Cheek.
2- Mortise is the Clear Distance between Cheeks
3- Swallow is the Opening Over the Sheave Thru. which the Rope Passes.
4- Breech is the End of the Block Opposite to the Swallow.
5- Becket is the Fitting which Takes the Standing Part of the Rope, the Thimble is that Part of the Becket Over which the Rope Eye is Spliced.
6- A Fitting the Outer End of which is in the Plane of the Sheave is a Front Fitting; One at Right Angles to the Plane of the Sheave is a Side Fitting.
7- An Upset Shackle is One the Bow of which Passes Thru. the Strap Bail or Intermediate Fitting wereas in the Regular Shackle the Shackle Pin Passes Thru. the Adjacent Part.
8- When Ordering Blocks Observe the Following.
Procedure:-
1st. State Whether Wood or Metal.
2nd. State Size, also Whether Single, Double, Etc.
3rd. State the Rig No. as shown on this Plan.
4th. State Whether with or without Becket.
Example:-
Block, Wood, 8 Inch Double, Rig No.4 with Becket.
9- Details of Fittings for Both Standard and Non-Standard Rigs Appear on Standard Plans of Wood Blocks for the Respective Sizes.
11- Blocks Marked ⊗ will be Carried in Stock. Blocks Marked "x" may be Manufactured without Specific Approval of the Bureau. Blocks not Marked "x" will not be Manufactured except upon Specific Approval.

§ 2. TABLES.

Table I.

Manila Rope, Plain Laid, 3 Strand.

Name and circumference.	Length of coil (approximate).	Gross weight of coil (approximate).	Weight per foot (maximum).	Length per pound (minimum).	Breaking strength (minimum).
Inches	*Feet*	*Pounds*	*Pounds*	*Feet*	*Pounds*
⅝ (6 thread)	3,000	45	0.015	66.6	450
¾ (6 ")	2,750	55	.020	50.0	600
1 (9 ")	2,250	65	.029	34.5	1,000
1 ⅛ (12 ")	1,620	66	.041	24.4	1,350
1 ¼ (15 ")	1,200	63	.053	19.0	1,750
1 ½ (21 ")	1,200	90	.075	13.3	2,650
1 ¾	1,200	125	.104	9.61	3,450
2	1,200	160	.133	7.50	4,400
2 ¼	1,200	200	.167	6.00	5,400
2 ½	1,200	234	.195	5.13	6,500
2 ¾	1,200	270	.225	4.45	7,700
3	1,200	324	.270	3.71	9,000
3 ¼	1,200	375	.313	3.20	10,500
3 ½	1,200	432	.360	2.78	12,000
3 ¾	1,200	502	.418	2.40	13,500
4	1,200	576	.480	2.09	15,000
4 ½	1,200	720	.600	1.67	18,500
5	1,200	893	.744	1.34	22,500
5 ½	1,200	1,073	.895	1.12	26,500
6	1,200	1,290	1.08	.930	31,000
7	1,200	1,752	1.46	.685	41,000
8	1,200	2,290	1.91	.524	52,000
9	1,200	2,900	2.42	.414	64,000
10	1,200	3,590	2.99	.335	77,000
11	1,200	4,400	3.67	.273	91,000
12	1,200	5,225	4.36	.230	105,000

Table II.

Ratline Stuff and Similar Material Made Up on Special Orders of Tarred American Hemp.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.
	Pound.	*Fms.*	*Pounds.*	*Pounds.*
6-thread, ¾-inch	0.18	100	18	650
9-thread, 1-inch	.25	100	25	1,000
12-thread, 1⅛-inch	.35	100	35	1,400
15-thread, 1¼-inch	.45	100	45	1,800
18-thread, 1⅜-inch	.53	100	53	2,100
21-thread, 1½-inch	.60	100	60	2,400

4-strand plain laid tarred hemp rope is 2 inches in circumference, weighs not more than 0.96 pound per fathom, is put up in 200-fathom coils and has a breaking strength of not less than 3,085 pounds.

It is used for pilot ladders and rigging for small boats.

Table III.

Seizing Stuff—Tarred American Hemp.

Use: For serving manila and wire where material more pliable than ratline is required.

Name and circumference.	Weight per fathom.	Length of coil.	Breaking strain.	Remarks.
	Pound.	*Fms.*	*Pounds.*	
4-thread, ½-inch...	0.095	100	365	5 lengths to package.
6-thread, ⅝-inch...	.12	100	560	4 lengths to package.
9-thread, ⅞-inch...	.165	100	700	3 lengths to package.
12-thread, 1-inch...	.21	100	955	3 lengths to package.

Table IV.

Halliards, Signal, Braided.

Detail Requirements.

(*a*) Braided signal halliards shall contain eight strands of three-ply flax twine.

(*b*) Braided signal halliards shall conform to the requirements of the following table:

Circumference.*	Minimum breaking strength.	Minimum feet per pound.
Inch	*Pounds*	
1	1200	40
¾	800	60

* A tolerance of plus 5 per cent in circumference will be allowed.

(*c*) Signal halliards shall be supplied in coils of the largest commercial size, unless otherwise specified.

Table V.

Lines, Cotton, Braided.

(lead line and taffrail log line)

Detail Requirements.

Cotton braided lines shall conform to the following requirements:

Type.	Approximate circumference.	Number of 14-ply twines per strand.	Length of coil.	Feet per pound, minimum.	Breaking strength, minimum.	Stretch in 8 inches, 200 pounds, maximum.
	Inch.		*Feet.*		*Pounds*	*Inches.*
A. Lead line (boat and ship)	¾	1	150* / 200†	60	220	1¼
B. Taffrail log line.....	1	2	200 / 400 / 600	33	400	1¾
C. Deep sea lead line.....	1	2	900	33	400	1¾

* Boat. † Ship.

Table VI.

Line, Fishing

Detail Requirements.

(*a*) Fishing line shall conform to following table:

Size.	Circumference.*	Ply flax twine.		Length of coil.	Feet per pound (minimum).	Breaking strength (minimum).
	Inch.	*Ply.*	*Fold.*	*Feet.*		*Pounds.*
000	1/2	3	6	210	100	285
00	15/32	3	5	210	120	260
0	13/32	3	4	210	150	235
1	5/16	3	2	210	300	123
2	7/32	4	Single.	210	400	110
3	3/16	3	Single.	210	600	60

* Tolerance, 5 per cent circumference.

TABLE VII.

COTTON ROPE

Circumference, inch.	Tolerance, inch.	Feet per pound (minimum).	Breaking strength, (minimum), pounds.
5/16	±1/64	270	130
3/8	±1/64	160	170
1/2	±1/32	140	200
3/4	±3/32	57	500

TABLE VIII.

MISCELLANEOUS SMALL STUFF.

Untarred marline for serving awning backbones is made up in 20-pound coils, weight per fathom, 0.028 pound; six packages packed for shipment in bale weighing 60 pounds. It is used for serving wire up to 7/16″ diameter.

Yacht marline is tarred; is used for small work in rigging lofts; weight per fathom, 0.0195 pound; coil, 20 pounds, or as required.

Marline tarred.—Weight per fathom, 0.0327 pound; coil, 20 pounds, or as required. It is used for serving wire 7/16″ to 1″ diameter.

House line. Weight per fathom, 0.0519 pound; coil, 20 pounds, or as required.

Round line. Weight per fathom, 0.066 pound; lengths of 60 fathoms; weight, 4 pounds coil, 50 pounds, or as required.

Spun yarn, 2-yarn. Weight per fathom, 0.528 pound; coil 20 pounds, or as required.

Spun yarn, 3-yarn. Weight per fathom, 0.073 pound; coil, 20 pounds, or as required.

TABLE IX.

MANILA ROPE.

(*a*) No fiber other than manila or Abaca (Musa textilis) of the grades listed in the following table shall be used.

Government grade.	Values.
D	200
E	150
F and S1	125
I and S2	100
J1	55

Mixtures of the above-mentioned grades are allowable, provided certain average values result, and these average values shall be determined by multiplying the percentage of each grade in the mixture by its value as shown in the above table and taking the sum of these products.

(*b*) For rope 2 inches in circumference and larger, the average value of the mixture shall not be less than 100, and in addition not more than 12½ per cent of Grade J1, and not more than a total of 77½ per cent of Grades, J1, I, and S2 shall be used.

(*c*) For rope from 1¼ to 1¾ inches in circumference, inclusive, the average value of the mixture shall not be less than 120, and no Grade J1, and not over 40 per cent of Grades I and S2 shall be used.

(*d*) For rope up to 1⅛ inches in circumference, inclusive, the average value of the mixture shall not be less than 137, and no Grade J1, I, or S2 shall be used.

Table X.

Rope, Wire.

A. Applicable Specifications

Navy Department General Specifications for Inspection of Material, together with Appendix II (Metals), of the issue in effect on date of invitation for bids, forms a part of this specification, and bidders and contractors should provide themselves with the necessary copies.

B. Types

Wire rope shall be of the following types, as specified:

a. 6 by 19 wire rope, extra strong cast steel, uncoated or galvanized, fiber core.

b. 6 by 19 wire rope, high-grade plow steel, uncoated or galvanized, fiber core.

c. 6 by 19 wire rope, phosphor bronze, fiber core.

d. 6 by 37 wire rope, extra strong cast steel, uncoated or galvanized, fiber core.

e. 6 by 37 wire rope, high-grade plow steel, uncoated or galvanized, fiber core.

f. 6 by 12 wire rope, cast steel, galvanized, fiber core.

g. 6 by 12 wire rope, high-grade plow steel, galvanized, fiber core.

h. 6 by 12 wire rope, phosphor bronze, fiber core.

i. 6 by 24 wire rope, cast steel, galvanized, fiber core.

j. 6 by 24 wire rope, high-grade plow steel, galvanized, fiber core.

k. 6 by 7 wire rope, extra strong cast steel, galvanized, fiber core.

l. 5 by 19 marline covered wire rope, extra strong cast steel, uncoated, fiber core.

m. 1 by 7 seizing strand, galvanized.

n. 1 by 19 seizing strand, galvanized.

Table XI.

Type A, 6 by 19 Wire Rope, Extra Strong Cast Steel, Uncoated or Galvanized, Fiber Core

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Uncoated		Galvanized	
					Nominal breaking strength.	Minimum breaking strength.	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
1/4	0.250	3/4	0.10	0.60	2.3	4,480	2.07	4,040
5/16	.312	1	.16	.96	3.5	6,820	3.15	6,140
3/8	.375	1 1/8	.23	1.38	5.0	9,800	4.50	8,780
7/16	.438	1 1/4	.31	1.86	6.6	12,900	5.94	11,600
1/2	.500	1 1/2	.40	2.40	8.5	16,600	7.65	14,900
9/16	.562	1 3/4	.51	3.06	10.6	20,700	9.54	18,600
5/8	.625	2	.63	3.78	13.1	25,500	11.8	23,000
3/4	.750	2 1/4	.90	5.40	18.7	36,500	16.8	32,800
7/8	.875	2 3/4	1.23	7.38	25.4	49,500	22.9	44,700
1	1.000	3	1.60	9.60	33.0	64,400	29.7	57,900
1 1/8	1.125	3 1/2	2.03	12.18	41.5	80,900	37.4	72,900
1 1/4	1.250	4	2.50	15.00	51.0	99,400	45.9	89,500
1 3/8	1.375	4 1/4	3.03	18.18	61.5	112,000	55.4	108,000
1 1/2	1.500	4 3/4	3.60	21.60	72.5	141,000	65.2	127,000
1 5/8	1.625	5	4.23	25.38	85	166,000	76.5	149,000
1 3/4	1.750	5 1/2	4.90	29.40	98	191,000	88.2	172,000
1 7/8	1.875	5 3/4	5.63	33.78	112	218,000	101	197,000
2	2.000	6 1/4	6.40	38.40	127	248,000	114	223,000
2 1/4	2.250	7 1/8	8.10	48.60	160	312,000	144	281,000
2 1/2	2.500	7 7/8	10.00	60.00	195	380,000	176	342,000
2 3/4	2.750	8 5/8	12.10	72.60	234	456,000	211	411,000

Table XII.

Type B, 6 by 19 Wire Rope, High-grade Plow Steel, Uncoated or Galvanized, Fiber Core

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet)	Uncoated		Galvanized	
					Nominal breaking strength.	Minimum breaking strength.	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
1/4	0.250	3/4	0.10	0.60	2.9	5,660	2.61	5,090
5/16	.312	1	.16	.96	4.5	8,780	4.05	7,900
3/8	.375	1 1/8	.23	1.38	6.3	12,300	5.67	11,100
7/16	.438	1 1/4	.31	1.86	8.4	16,400	7.56	14,700
1/2	.500	1 1/2	.40	2.40	10.8	21,100	9.72	19,000
9/16	.562	1 3/4	.51	3.06	13.5	26,300	12.2	23,800
5/8	.625	2	.63	3.78	16.6	32,400	14.9	29,100
3/4	.750	2 1/4	.90	5.40	23.7	46,200	21.3	41,500
7/8	.875	2 3/4	1.23	7.38	32.2	62,800	29.0	56,600
1	1.000	3	1.60	9.60	42.0	81,900	37.8	73,700
1 1/8	1.125	3 1/2	2.03	12.18	53.0	103,000	47.7	93,000
1 1/4	1.250	4	2.50	15.00	65.0	127,000	58.5	114,000
1 3/8	1.375	4 1/4	3.03	18.18	78.5	153,000	70.6	138,000
1 1/2	1.500	4 3/4	3.60	21.60	92.5	180,000	83.2	162,000
1 5/8	1.625	5	4.23	25.38	108	211,000	97.2	190,000
1 3/4	1.750	5 1/2	4.90	29.40	124	242,000	112	218,000
1 7/8	1.875	5 3/4	5.63	33.78	142	277,000	128	249,000
2	2.000	6 1/4	6.40	38.40	161	314,000	145	283,000
2 1/4	2.250	7 1/8	8.10	48.60	202	394,000	182	355,000
2 1/2	2.500	7 7/8	10.00	60.00	246	480,000	221	432,000
2 3/4	2.750	8 5/8	12.10	72.60	294	573,000	265	516,000

Table XIII.

Type C, 6 by 19 Wire Rope, Phosphor Bronze, Fiber Core

Nominal diameter, minimum diameter.	Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
Inches. *Inches.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
1/4 0.250	3/4	0.11	0.66	1.19	2,140
5/16 .312	1	.16	.96	1.84	3,310
3/8 .375	1 1/8	.23	1.38	2.62	4,720
7/16 .438	1 1/4	.32	1.92	3.54	6,370
1/2 .500	1 1/2	.41	2.46	4.61	8,300
9/16 .562	1 3/4	.52	3.12	5.75	10,400
5/8 .625	2	.64	3.84	7.08	12,700
3/4 .750	2 1/4	.92	5.52	9.98	18,000
13/16 .812	2 1/2	1.08	6.48	11.6	20,900
7/8 .875	2 3/4	1.26	7.56	13.4	24,100

Table XIV.

Type D, 6 by 37 Wire Rope, Extra Strong Cast Steel, Uncoated or Galvanized, Fiber Core

Nominal diameter, minimum diameter.	Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom. (6 feet)	Uncoated		Galvanized	
				Nominal breaking strength.	Minimum breaking strength.	Nominal breaking strength.	Minimum breaking strength.
In. *In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*	*Tons (2,000 pounds)*	*Pounds.*
3/8 0.375	1 1/8	0.22	1.32	4.90	9,560	4.41	8,600
7/16 .438	1 1/4	.30	1.80	6.60	12,900	5.94	11,600
1/2 .500	1 1/2	.39	2.34	8.40	16,400	7.56	14,700
9/16 .562	1 3/4	.49	2.94	10.5	20,500	9.45	18,400
5/8 .625	2	.61	3.66	12.8	25,000	11.5	22,400
3/4 .750	2 1/4	.87	5.22	18.1	35,300	16.3	31,800
7/8 .875	2 3/4	1.19	7.14	24.2	47,200	21.8	42,500
1 1.000	3	1.55	9.30	31.5	61,400	28.4	55,400
1 1/8 1.125	3 1/2	1.96	11.76	39.7	77,400	35.7	69,600
1 1/4 1.250	4	2.42	14.52	48.9	95,400	44.0	85,800
1 3/8 1.375	4 1/4	2.93	17.58	59.0	115,000	53.1	104,000
1 1/2 1.500	4 3/4	3.49	20.94	70.0	136,000	63.0	123,000
1 5/8 1.625	5	4.09	24.54	82.0	160,000	73.8	144,000
1 3/4 1.750	5 1/2	4.75	28.50	95.0	185,000	85.5	167,000
1 7/8 1.875	5 3/4	5.45	32.70	108.5	212,000	97.6	190,000
2 2.000	6 1/4	6.20	37.20	123.0	240,000	111	216,000
2 1/4 2.250	7 1/8	7.85	47.10	153.0	298,000	138	269,000
2 1/2 2.500	7 7/8	9.69	58.14	188.0	367,000	169	330,000
2 3/4 2.750	8 5/8	11.72	70.32	226.0	441,000	203	397,000

Table XV.

Type E, 6 by 37 Wire Rope, High-grade Plow Steel, Uncoated or Galvanized, Fiber Core

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom. (6 feet)	Uncoated		Galvanized	
					Nominal breaking strength.	Minimum breaking strength.	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*	*Tons (2,000 pounds)*	*Pounds.*
1/4	0.250	3/4	0.10	0.60	2.4	4,620	2.10	4,180
5/16	.312	1	.15	.90	4.1	7,900	3.84	7,500
3/8	.375	1 1/8	.22	1.32	6.1	11,900	5.49	10,700
7/16	.438	1 1/4	.30	1.80	8.3	16,200	7.47	14,600
1/2	.500	1 1/2	.39	2.34	10.6	20,700	9.54	18,600
9/16	.562	1 3/4	.49	2.94	13.2	25,700	11.9	23,200
5/8	.625	2	.61	3.66	16.1	31,400	14.5	28,200
3/4	.750	2 1/2	.87	5.22	22.8	44,500	20.5	40,000
7/8	.875	2 3/4	1.19	7.14	30.5	59,500	27.4	53,400
1	1.000	3	1.55	9.30	39.5	77,000	35.6	69,400
1 1/8	1.125	3 1/2	1.96	11.76	49.9	97,300	44.9	87,600
1 1/4	1.250	4	2.42	14.52	61.5	120,000	55.4	108,000
1 3/8	1.375	4 1/4	2.93	17.58	74.3	145,000	66.9	130,000
1 1/2	1.500	4 3/4	3.49	20.94	88.2	172,000	79.4	155,000
1 5/8	1.625	5	4.09	24.54	103.3	201,000	93	181,000
1 3/4	1.750	5 1/2	4.75	28.50	119.5	233,000	108	210,000
1 7/8	1.875	5 3/4	5.45	32.70	137	267,000	123	240,000
2	2.000	6 1/4	6.20	37.20	155	302,000	140	272,000
2 1/4	2.250	7 1/8	7.85	47.10	194	378,000	175	340,000
2 1/2	2.500	7 7/8	9.69	58.14	237	462,000	213	416,000
2 3/4	2.750	8 5/8	11.72	70.32	285	556,000	256	500,000

Table XVI.

Type F, 6 by 12 Wire Rope, Cast Steel, Galvanized, Fiber Core

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
5/16	0.312	1	0.10	0.60	1.76	3,430
3/8	.375	1 1/8	.15	.90	2.47	4,820
7/16	.438	1 1/4	.20	1.20	3.29	6,420
1/2	.500	1 1/2	.26	1.56	4.23	8,250
9/16	.562	1 3/4	.33	1.98	5.26	10,300
5/8	.625	2	.41	2.46	6.46	12,600
3/4	.750	2 1/4	.59	3.54	9.26	18,100
13/16	.812	2 1/2	.69	4.14	10.8	21,100
7/8	.875	2 3/4	.80	4.80	12.5	24,400
1	1.000	3	1.05	6.30	16.3	31,800
1 1/16	1.062	3 1/4	1.19	7.14	18.3	35,700
1 1/8	1.125	3 1/2	1.33	7.98	20.5	40,000
1 3/16	1.188	3 3/4	1.48	8.88	22.8	44,500
1 1/4	1.250	4	1.64	9.84	25.1	48,900
1 3/8	1.375	4 1/4	1.99	11.94	30.2	58,900
1 7/16	1.438	4 1/2	2.17	13.02	33.0	64,400
1 1/2	1.500	4 3/4	2.36	14.16	35.8	69,800
1 5/8	1.625	5	2.77	16.62	41.8	81,500
1 11/16	1.688	5 1/4	2.99	17.94	45.0	87,800
1 3/4	1.750	5 1/2	3.22	19.32	48.3	94,200
1 13/16	1.812	5 3/4	3.45	20.70	51.7	101,000
1 15/16	1.938	6	3.94	23.64	59.0	115,000
2	2.000	6 1/4	4.20	25.20	62.7	122,000
2 1/16	2.062	6 1/2	4.47	26.82	66.6	130,000

TABLE XVII.

TYPE G, 6 BY 12 WIRE ROPE, HIGH-GRADE PLOW STEEL, GALVANIZED, FIBER CORE

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
1/4	0.250	3/4	0.07	0.42	1.59	3,100
5/16	.312	1	.10	.60	2.46	4,800
3/8	.375	1 1/8	.14	.84	3.46	6,750
7/16	.438	1 1/4	.20	1.20	4.61	8,990
1/2	.500	1 1/2	.26	1.56	5.9	11,500
9/16	.562	1 3/4	.33	1.98	7.4	14,400
5/8	.625	2	.42	2.52	9.1	17,700
3/4	.750	2 1/4	.59	3.54	13.0	25,400
13/16	.812	2 1/2	.68	4.08	15.5	30,200
7/8	.875	2 3/4	.80	4.80	17.7	34,500
1	1.000	3	1.05	6.30	23.0	44,800
1 1/16	1.062	3 1/4	1.18	7.08	26.0	50,700
1 1/8	1.125	3 1/2	1.33	7.98	29.1	56,700
1 3/16	1.188	3 3/4	1.47	8.82	32.3	63,000
1 1/4	1.250	4	1.63	9.78	35.6	69,400
1 3/8	1.375	4 1/4	2.00	12.00	43.0	83,800
1 7/16	1.438	4 1/2	2.16	12.96	46.8	91,300
1 1/2	1.500	4 3/4	2.36	14.16	50.9	99,300
1 5/8	1.625	5	2.76	16.56	59.2	115,000
1 11/16	1.688	5 1/4	2.94	17.64	63.6	124,000
1 3/4	1.750	5 1/2	3.23	19.38	68.2	133,000
1 13/16	1.812	5 3/4	3.42	20.52	72.8	142,000
1 15/16	1.938	6	3.83	22.98	83.0	162,000
2	2.000	6 1/4	4.20	25.20	88.3	172,000
2 1/16	2.062	6 1/2	4.43	26.58	93.4	182,000

TABLE XVIII.

TYPE H, 6 BY 12 WIRE ROPE, PHOSPHOR BRONZE, FIBER CORE

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
1/4	0.250	3/4	0.075	0.45	0.74	1,330
5/16	.312	1	.115	.69	1.14	2,050
3/8	.375	1 1/8	.168	1.01	1.69	3,040
7/16	.438	1 1/4	.227	1.36	2.29	4,120
1/2	.500	1 1/2	.295	1.77	2.96	5,330
9/16	.562	1 3/4	.370	2.22	3.72	6,700
5/8	.625	2	.460	2.76	4.56	8,210
3/4	.750	2 1/4	.660	3.96	6.40	11,500
13/16	.812	2 1/2	.766	4.60	7.15	12,900
7/8	.875	2 3/4	.895	5.37	8.30	14,900

TABLE XIX.

TYPE I, 6 BY 24 WIRE ROPE, CAST STEEL, GALVANIZED, FIBER CORE

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
3/4	0.750	2 1/4	0.78	4.68	13.6	26,500
13/16	.812	2 1/2	.91	5.46	15.8	30,800
7/8	.875	2 3/4	1.06	6.36	18.3	35,700
1	1.000	3	1.38	8.28	23.7	46,200
1 1/16	1.062	3 1/4	1.56	9.36	26.7	52,100
1 1/8	1.125	3 1/2	1.75	10.50	29.9	58,300
1 3/16	1.188	3 3/4	1.95	11.70	33.2	64,700
1 1/4	1.250	4	2.16	12.96	36.7	71,600
1 3/8	1.375	4 1/4	2.61	15.66	44.4	86,600
1 7/16	1.438	4 1/2	2.85	17.10	48.4	94,400
1 1/2	1.500	4 3/4	3.11	18.66	52.6	103,000
1 5/8	1.625	5	3.64	21.84	61.6	120,000
1 11/16	1.688	5 1/4	3.93	23.58	66.3	129,000
1 3/4	1.750	5 1/2	4.23	25.38	71.2	139,000
1 13/16	1.812	5 3/4	4.53	27.18	76.2	149,000
1 15/16	1.938	6	5.18	31.08	86.6	169,000
2	2.000	6 1/4	5.52	33.12	92.0	179,000
2 1/16	2.062	6 1/2	5.87	35.22	98.0	191,000

TABLE XX.

TYPE J, 6 BY 24 WIRE ROPE, HIGH-GRADE PLOW STEEL, GALVANIZED, FIBER CORE

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
3/4	0.750	2 1/4	0.78	4.68	18.9	36,900
13/16	.812	2 1/2	.90	5.40	22.0	42,900
7/8	.875	2 3/4	1.05	6.30	25.3	49,300
1	1.000	3	1.38	8.28	32.8	64,000
1 1/16	1.062	3 1/4	1.56	9.36	37.0	72,200
1 1/8	1.125	3 1/2	1.75	10.50	41.4	80,700
1 3/16	1.188	3 3/4	1.96	11.76	46.1	89,900
1 1/4	1.250	4	2.17	13.02	51.0	99,400
1 3/8	1.375	4 1/4	2.65	15.90	61.6	120,000
1 7/16	1.438	4 1/2	2.90	17.40	67.2	131,000
1 1/2	1.500	4 3/4	3.15	18.90	73.1	143,000
1 5/8	1.625	5	3.68	22.08	85.6	167,000
1 11/16	1.688	5 1/4	3.97	23.82	92.1	180,000
1 3/4	1.750	5 1/2	4.27	25.62	99.0	193,000
1 13/16	1.812	5 3/4	4.57	27.42	106.0	207,000
1 15/16	1.938	6	5.22	31.32	121.0	235,000
2	2.000	6 1/4	5.55	33.30	129.0	251,000
2 1/16	2.062	6 1/2	5.77	34.62	136.0	264,000

TABLE XXI.

TYPE K, 6 BY 7 WIRE ROPE, EXTRA STRONG CAST STEEL, GALVANIZED, FIBER CORE

Nominal diameter, minimum diameter.		Approximate circumference.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*Inches.*	*Pounds.*	*Pounds.*	*Tons (2,000 pounds).*	*Pounds.*
9/32	0.281	7/8	0.12	0.72	2.45	4,780
5/16	.312	1	.15	.90	3.02	5,890
3/8	.375	1 1/8	.21	1.26	4.23	8,250
7/16	.438	1 1/4	.29	1.74	5.67	11,100
1/2	.500	1 1/2	.38	2.28	7.38	14,400
9/16	.562	1 3/4	.48	2.88	9.27	18,100
5/8	.625	2	.59	3.54	11.3	22,000
11/16	.688	2 1/8	.72	4.32	13.7	26,700
3/4	.750	2 1/4	.84	5.04	16.3	31,800
7/8	.875	2 3/4	1.15	6.90	22.1	43,100
1	1.000	3	1.50	9.00	28.7	56,000
1 1/8	1.125	3 1/2	1.90	11.40	36.0	70,200
1 1/4	1.250	4	2.34	14.04	43.8	85,400
1 3/8	1.375	4 1/4	2.84	17.04	52.4	102,000
1 1/2	1.500	4 3/4	3.38	20.28	61.8	121,000

TABLE XXII.

TYPE L, 5 BY 19 WIRE ROPE, MARLINE COVERED, EXTRA STRONG CAST STEEL, UNCOATED, FIBER CORE

Approximate diameter before serving.		Nominal diameter after serving.		Approximate weight per foot.	Approximate weight per fathom (6 feet).	Nominal breaking strength.	Minimum breaking strength.
In.	*In.*	*In.*	*In.*	*Pounds*	*Pounds*	*Tons (2,000 pounds)*	*Pounds*
1/4	0.250	9/16	0.562	0.21	1.26	2.1	4,100
3/8	.375	11/16	.688	.36	2.16	4.6	8,970
1/2	.500	13/16	.812	.51	3.06	7.8	15,200
9/16	.562	7/8	.875	.62	3.72	9.7	18,900
5/8	.625	1	1.000	.81	4.86	12.0	23,400
3/4	.750	1 1/8	1.125	1.10	6.60	17.1	33,300
7/8	.875	1 1/4	1.250	1.32	7.92	23.3	54,400
1	1.000	1 3/8	1.375	1.70	10.20	30.2	58,900
1 1/8	1.125	1 1/2	1.500	2.12	12.72	38.0	74,100
1 1/4	1.250	1 5/8	1.625	2.58	15.48	46.8	91,300
1 3/8	1.375	1 3/4	1.750	3.14	18.84	56.4	110,000
1 1/2	1.500	1 7/8	1.875	3.69	22.14	66.5	130,000
1 5/8	1.625	2	2.000	4.29	25.74	77.9	152,000
1 3/4	1.750	2 1/8	2.125	5.00	30.00	89.8	175,000

Table XXIII.

Type M, 1 by 7 Seizing Strand, Galvanized

Nominal diameter, minimum diameter.		Approximate diameter of wire.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Approximate weight of reel.	Approximate length of strand on reel.		Minimum breaking strength.
In.	*In.*	*Inch.*	*Pound.*	*Pound.*	*Pounds.*	*Feet.*	*Fathoms.*	*Pounds.*
1/16	0.062	0.022	0.010	0.06	50	5,000	834	140
3/32	.094	.032	.020	.12	50	2,500	416	300
1/8	.125	.042	.033	.20	50	1,500	250	530
5/32	.156	.052	.050	.30	50	1,000	166	810

Table XXIV.

Type N, 1 by 19 Seizing Strand, Galvanized

Nominal diameter, minimum diameter.		Approximate diameter of wire.	Approximate weight per foot.	Approximate weight per fathom (6 feet).	Approximate weight of reel.	Approximate length of strand on reel.		Minimum breaking strength.
In.	*In.*	*Inch*	*Pound*	*Pound*	*Pounds*	*Feet*	*Fathoms*	*Pounds*
3/16	0.188	0.042	0.083	0.50	100	1 200	200	1,100
1/4	.250	.052	.133	.80	100	750	125	1,900

TABLES XXV thru XXX
on Stainless Steel Wire
(1 x 19 and 7 x 19)
may be found on pages 846, 847 and 848
at end of book.

TABLE XXXI.

WIND DRAG IN POUNDS, SHIP HEADED INTO WIND

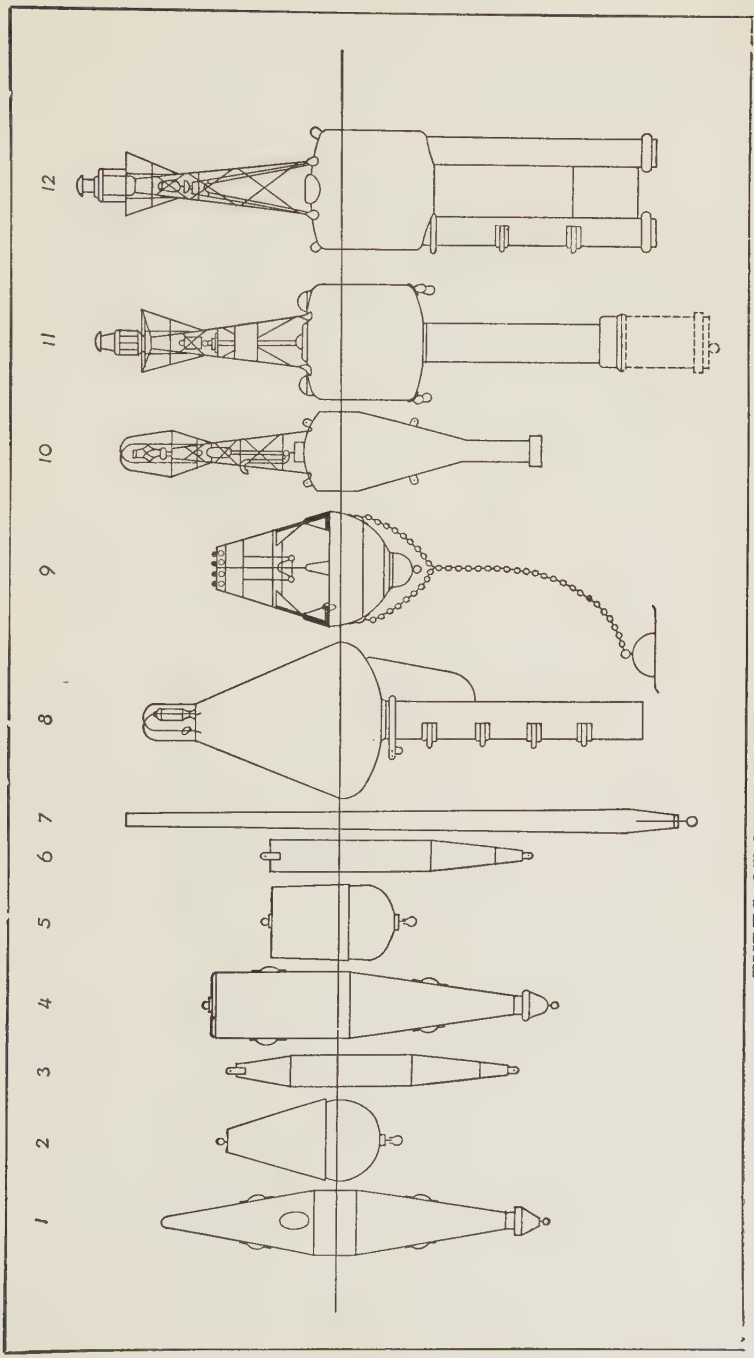
Beaufort No.	1	2	3	4	5	6	7	8	9	10	11	12
Wind Knots	2	4	9	13	18	23	30	37	44	51	59	65
BATTLESHIPS												
Maryland (BB46)	100	400	2000	4180	8010	13,100	22,300	33,800	47,900	64,300	86,100	104,400
Oklahoma (BB37)	100	410	2080	4330	8310	13,600	23,100	35,100	49,700	66,800	89,300	108,500
Pennsylvania (BB38)	100	400	2000	4180	8010	13,100	22,300	33,800	47,900	64,300	86,100	104,400
AIRCRAFT CARRIERS												
Lexington (CV2)	100	390	1960	4080	7820	12,800	21,700	33,100	46,700	62,800	84,000	102,000
Langley (CV1)	40	150	750	1570	3010	4,910	8,360	12,700	18,000	24,200	32,300	39,300
Ranger (CV4)	60	230	1140	2380	4560	7,450	12,700	19,300	27,300	36,600	49,000	59,500
Yorktown (CV5)	60	230	1180	2470	4730	7,730	13,200	20,000	28,300	38,000	50,900	61,700
Wasp (CV7)	60	230	1160	2420	4630	7,560	12,900	19,600	27,700	37,200	49,700	60,400
CRUISERS												
Omaha (CL4)	30	110	540	1120	2160	3,500	5,990	9,100	12,900	17,300	23,200	28,100
Indianapolis (CA35)	40	140	730	1520	2920	4,770	8,110	12,300	17,400	23,400	31,400	38,100
San Francisco (CA38)	30	130	640	1340	2570	4,190	7,130	10,800	15,300	20,600	27,600	33,500
Quincy (CA39)	30	130	640	1340	2570	4,190	7,130	10,800	15,300	20,600	27,600	33,500
St. Louis (CL49)	30	130	630	1320	2520	4,120	7,010	10,700	15,100	20,300	27,100	32,900
DESTROYERS												
Pruitt (DD347)	10	30	170	360	680	1,120	1,900	2,890	4,090	5,490	7,350	8,920
Farragutt (DD348)	10	40	210	430	820	1,340	2,290	3,480	4,920	6,610	8,840	10,700
Mahan (DD364)	10	40	210	430	820	1,340	2,290	3,480	4,920	6,610	8,840	10,700
Porter (DD356)	10	50	240	510	970	1,580	2,700	4,100	5,790	7,780	10,400	12,600
MISCELLANEOUS												
Fleet Oiler	50	190	950	1980	3800	6,210	10,600	16,100	22,700	30,500	40,800	49,600
Destroyer Tender	50	190	950	1980	3800	6,210	10,600	16,100	22,700	30,500	40,800	49,600
Ammunition Ship (AE1) (*Pyro*)	30	130	660	1380	2650	4,320	7,360	11,200	15,800	21,300	28,500	34,600
Erie (PG50)	20	60	300	630	1200	1,960	3,330	5,070	7,160	9,620	12,900	15,600
Tug (YT119)	10	20	100	220	410	670	1,140	1,740	2,460	3,300	4,420	5,370

TABLE XXXII.

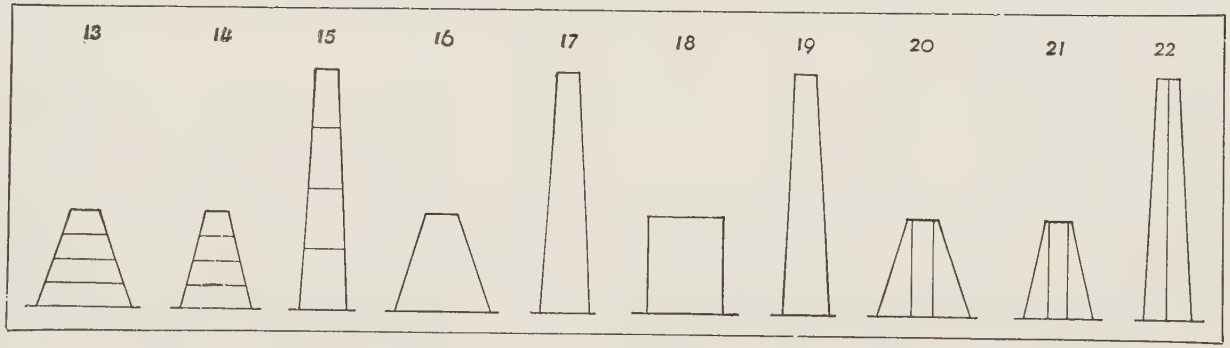
CURRENT DRAG IN POUNDS, SHIP HEADED INTO CURRENT

Current Knots	2	4	6	8	10
BATTLESHIPS					
Maryland (BB46)	2490	8,830	18,500	31,500	47,400
Oklahoma (BB37)	2130	7,560	15,900	26,900	40,600
Pennsylvania (BB38)	2460	8,730	18,300	31,100	46,900
AIRCRAFT CARRIERS					
Lexington (CV2)	3100	11,000	23,100	39,200	59,000
Langley (CV1)	1460	5,180	10,900	18,400	27,800
Ranger (CV4)	1800	6,400	13,400	22,800	34,300
Yorktown (CV5)	2210	7,830	16,400	27,900	42,000
Wasp (CV7)	1830	6,490	13,600	23,100	34,900
CRUISERS					
Omaha (CL4)	1240	4,410	9,300	15,700	23,700
Indianapol's (CA35)	1360	4,840	10,100	17,200	26,000
San Francisco (CA38)	1380	4,880	10,200	17,400	26,200
Quincy (CA39)	1310	4,650	9,770	16,600	25,600
St. Louis (CL49)	1390	4,920	10,300	17,500	26,400

Current Knots	2	4	6	8	10
DESTROYERS					
Pruitt (DD347)	370	1300	2,720	4,620	6,970
Farragutt (DD348)	410	1450	3,050	5,180	7,800
Mahan (DD364)	410	1470	3,080	5,230	7,880
Porter (DD356)	490	1730	3,620	6,150	9,270
MISCELLANEOUS					
Fleet Oiler	1820	6440	13,500	22,900	34,600
Destroyer Tender	1610	5700	12,000	20,300	30,600
Ammunition Ship (*Pyro*) AE1	310	1090	2,300	3,890	5,860
Erie (PG50)	450	1590	3,340	5,680	8,550
Tug (YT119)	100	360	750	1,260	1,900



TYPES OF BUOYS IN UNITED STATES WATERS.



TYPES OF BUOYS IN UNITED STATES WATERS.

NOTE: When it is desired to indicate which of two channels is preferable in the case of buoys marking obstructions, middle grounds, or junctions of channels, a CAN buoy, painted from top to bottom BLACK-RED-BLACK-RED, is used when the more important or preferable channel is to the right as approached from seaward, and a NUN buoy painted from top to bottom RED-BLACK-RED-BLACK, when the preferable channel is to the left. SPAR buoys, properly painted, may replace either of the above.

§ 3. BUOYAGE.

Plates **195**, **193, 197** and **198** show some of the systems of buoyage at present used by several maritime powers.

Canada.

The Canadian system of buoyage closely follows that of the United States. Conical buoys, when used, are always on the starboard side of the channel. All starboard-hand spar buoys have pointed tops and all port-hand buoys have flat tops; otherwise the shapes of buoys have no special significance at present.

Types of Buoys in United States Waters.

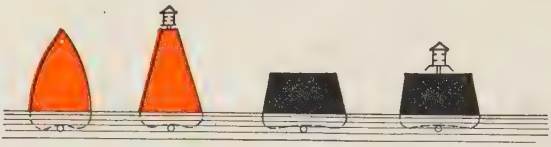
(Plates **195** and **196**.)

1. Tall Nun.
2. Nun.
3. Special Nun.
4. Tall Can.
5. Can.
6. Special Can.
7. Wooden Spar.
8. Whistling.
9. Bell.
10. Gas Lighted—Compressed Oil Gas.
11. Gas Lighted—Compressed Acetylene.
12. Gas Lighted—Compressed Acetylene.

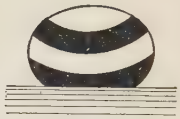
13. ISOLATED DANGERS — CAN colored from top to bottom BLACK-RED-BLACK-RED.
14. ISOLATED DANGERS — NUN colored from top to bottom RED-BLACK-RED-BLACK.
15. ISOLATED DANGERS — SPAR—properly painted may replace 13 or 14 above.

16. Starboard Hand (entering from seaward).
17. *Note*: Colored RED. (Even numbered).
18. PORT HAND (entering from seaward).
19. Colored BLACK. (Odd numbered).
20. MID-CHANNEL or FAIRWAY.
21. *Note*: 20 and 21 colored white-black-white.
22. 22 colored black-white from the left.

IRELAND

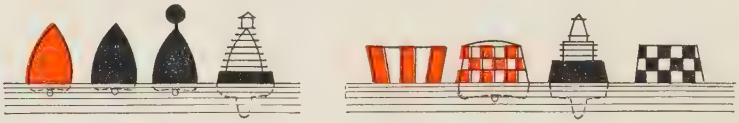


STARBOARD PORT



ISOLATED DANGERS
ENGLAND, IRELAND,
SCOTLAND

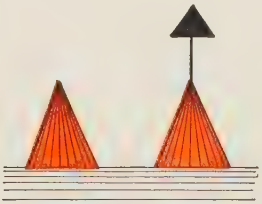
ENGLAND AND SCOTLAND



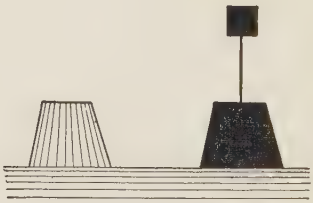
STARBOARD
(Starboard hand buoys are painted in any one color)

PORT
(These buoys are either single or parti-colored)

BRITISH BUOYS



STARBOARD HAND BUOYS



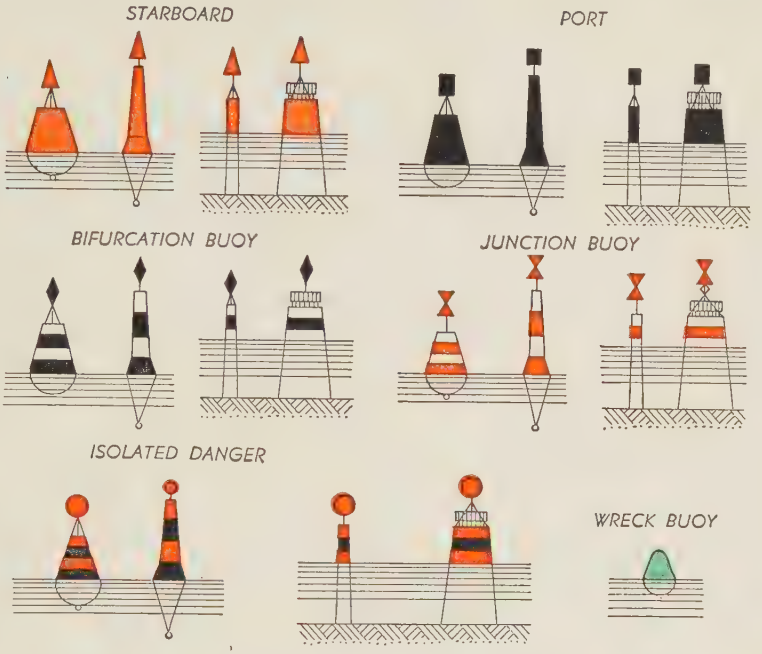
PORT HAND BUOYS
Either Black or Parti-colored

(OUTER END)

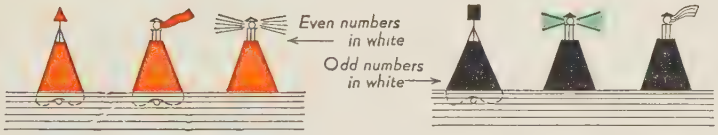
(INNER END)

MIDDLE GROUND BUOYS
All top marks are of a single dark color

INDIAN BUOYS



FRENCH BUOYS



STARBOARD HAND BUOYS — PORT HAND BUOYS

Light buoys and beacons marking channels generally show white fixed or white or red flashing lights

Conical buoys, with black and white horizontal bands, and surmounted by a diamond-shaped topmark, mark the lower ends of bars and shoals.

Conical buoys, with red and white horizontal bands, and surmounted by triangles pointed toward each other, mark the upper ends of bars and shoals.

Conical buoys, with red and black horizontal bands, and surmounted by a spherical topmark, mark isolated dangers.

Light buoys and beacons marking channels generally show green fixed or green or white flashing lights

JAPANESE BUOYS

§ 4. SAVING LIFE—BY ARTIFICIAL RESPIRATION—PRONE PRESSURE METHOD.

This method is published by the American National Red Cross on its Poster 1002 and has been approved by the following organizations: American Telephone and Telegraph Company; American Red Cross; American Gas Association; Bethlehem Steel Company; National Electric Light Association; National Safety Council; Bureau of Medicine and Surgery, Navy Department; Office of the Surgeon General, War Department; U. S. Bureau of Mines; Bureau of Standards and U. S. Public Health Service. Every Midshipman at the Naval Academy is instructed in its use.

* * * * * * *

"When the patient is removed from the water, gas, smoke or electric contact, *get to work at once with your own hands.* If possible, send for a physician.

"1. Lay the patient on his belly, one arm extended directly overhead, the other arm bent at elbow and with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing. (See Fig. 1, Plate **199**).

"2. Kneel straddling the patient's thighs with your knees placed at such a distance from the hip bones as will allow you to assume the position shown in Fig. 1.

"Place the palms of the hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position, and the tips of the fingers just out of sight. (See Fig. 1.)

"3. With arms held straight, swing forward slowly, so that the weight of your body is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the end of the forward swing. (See Fig. 2, Plate **199.**) Do not bend your elbows. This operation should take about two seconds.

"4. Now immediately swing backward, so as to remove the pressure completely. (See Fig. 3, Plate **199.**)

"5. After two seconds, swing forward again. Thus repeat deliberately twelve to fifteen times a minute the double movement of compression and release, a complete respiration in four or five seconds.

"6. Continue artificial respiration without interruption until

natural breathing is restored, if necessary, four hours or longer, or until a physician declares the patient is dead.

"7. As soon as this artificial respiration has been started and while it is being continued, an assisant should loosen any tight clothing about the patient's neck, chest, or waist. *Keep the patient warm.* Do not give any liquids whatever by mouth until the patient is fully conscious.

"8. To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up. If the doctor has not arrived by the time the patient has revived, he should be given some stimulant, such as one teaspoonful of aromatic spirits of ammonia in a small glass of water or a hot drink of coffee or tea, etc. The patient should be kept warm.

"9. Resuscitation should be carried on at the nearest possible point to where the patient received his injuries. He should not be moved from this point until he is breathing normally of his own volition and then moved only in a lying position. Should it be necessary, due to extreme weather conditions, etc., to move the patient before he is breathing normally, resuscitation should be carried on during the time he is being moved.

"10. A brief return of natural respiration is not a certain indication for stopping the resuscitation. Not infrequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched and if natural breathing stops, artificial respiration should be resumed at once.

"11. In carrying out resuscitation it may be necessary to change the operator. This change must be made without losing the rhythm of respiration. By this procedure no confusion results at the time of change of operator, and a regular rhythm is kept up."

Note. The above is an exact copy of the quoted *Poster 1002* but the additional instructions should be followed when the unconsciousness has been caused by one of the respective accidents:

Gas Asphyxiation. In case of gas asphyxiation remove the victim from the poisonous atmosphere. If breathing has stopped, or if it is slow and irregular, begin artificial respiration immediately at the nearest place where *fresh air* can be obtained. Notify the medical officer at once and send for oxygen. Keep the patient prone even though conscious.

Electric Shock. Usually electric shock does not kill in-

Fig. 1.

Fig. 2.

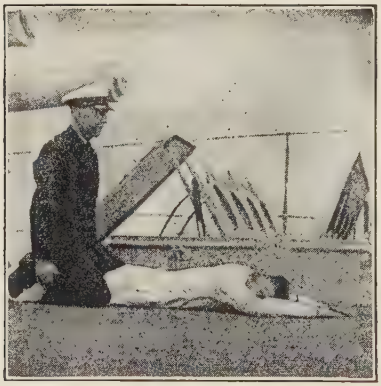


Fig. 3.

Fig. 4.

REVIVING THE APPARENTLY DEAD.

stantly. Life can often be saved even though breathing has stopped.

(1) *Free the victim from the circuit immediately.* Use a dry non-conductor (rubber gloves, clothing, rope, board) to move either the victim or the wire. Beware of using metal or moist material. Shut off the current. If necessary to cut a live wire use an ax or hatchet with a dry wooden handle and turn your face away from the electrical flash.

(2) *Attend instantly to the victim's breathing.* Begin artificial respiration at once, on the spot. Do not stop to loosen clothing; every moment counts. Feel with your finger in his mouth and throat for foreign bodies—tobacco, false teeth, etc.—and remove them. If the mouth is tightly shut pay no attention to it until it can be attended to without interfering with the application of artificial respiration.

Drowning. (1) In case of drowning, as soon as the victim is taken from the water place him face downward. Clasp your hands under his stomach and lift his body several times, letting the head hang down, thus draining the stomach, throat, and lungs. (Plate **199,** Fig. 4.)

(2) Quickly wipe out the mouth and throat with your fingers. Remove any foreign body. Do not waste a second.

(3) Begin artificial respiration at once and continue without interruption.

§ 5. INSTRUCTIONS FOR SAVING DROWNING PERSONS BY SWIMMING TO THEIR RELIEF.

1. When you approach a person drowning in the water assure him with a loud and firm voice that he is safe.

2. Before jumping in to save him, divest yourself as far and as quickly as possible of all clothes; tear them off if necessary; but if there is not time, loose at all events the foot of your drawers, if they are tied, as, if you do not do so, they will fill with water and drag you.

3. On swimming to a person in the sea, if he be struggling do not seize him then, but keep off for a few seconds till he gets quiet, for it is sheer madness to take hold of a man when he is struggling in the water, and if you do you run a great risk.

4. Then get close to him and take fast hold of the hair of his head, turn him as quickly as possible onto his back, give him a sudden pull, and this will cause him to float, then throw yourself on your back also and swim for shore, both hands having

hold of his hair, you on your back and he also on his, and of course his back to your stomach. In this way you will get sooner and safer ashore than by any other means, and you can easily thus swim with two or three persons; a good swimmer has, as an experiment, done it with four, and gone with them 40 or 50 yards in the sea. One great advantage of this method is that it enables you to keep your head up and also to hold the person's head up you are trying to save. It is of primary importance that you take fast hold of the hair and throw both the person and yourself on your backs. After many experiments, it is usually found preferable to all other methods. You can in this manner float nearly as long as you please, or until a boat or other help can be obtained.

5. It is believed there is no such thing as a *death grasp*; at least it is very unusual to witness it. As soon as a drowning man begins to get feeble and to lose his recollection, he gradually slackens his hold until he quits it altogether. No apprehension need, therefore, be felt on that head when attempting to rescue a drowning person.

6. After a person has sunk to the bottom, if the water be smooth, the exact position where the body lies may be known by the air bubbles, which will occasionally rise to the surface, allowance being made of course for the motion of the water, if in a tideway or stream, which will have carried the bubbles out of a perpendicular course in rising to the surface. Oftentimes a body may be regained from the bottom, before too late for recovery, by diving for it in the direction indicated by these bubbles.

7. On rescuing a person by diving to the bottom, the hair of the head should be seized by one hand only, and the other used in conjunction with the feet in raising yourself and the drowning person to the surface.

8. If in the sea, it may sometimes be a great error to try to get to land. If there be a strong "outsetting" tide, and you are swimming either by yourself or having hold of a person who cannot swim, then get on your back and float till help comes. Many a man exhausts himself by stemming the billows for the shore on a back-going tide, and sinks in the effort, when, if he had floated, a boat or other aid might have been obtained.

9. These instructions apply alike to all circumstances, whether as regards the roughest sea or smooth water.

§ 6. INDICATIONS OF THE APPROACH OF A HURRICANE.

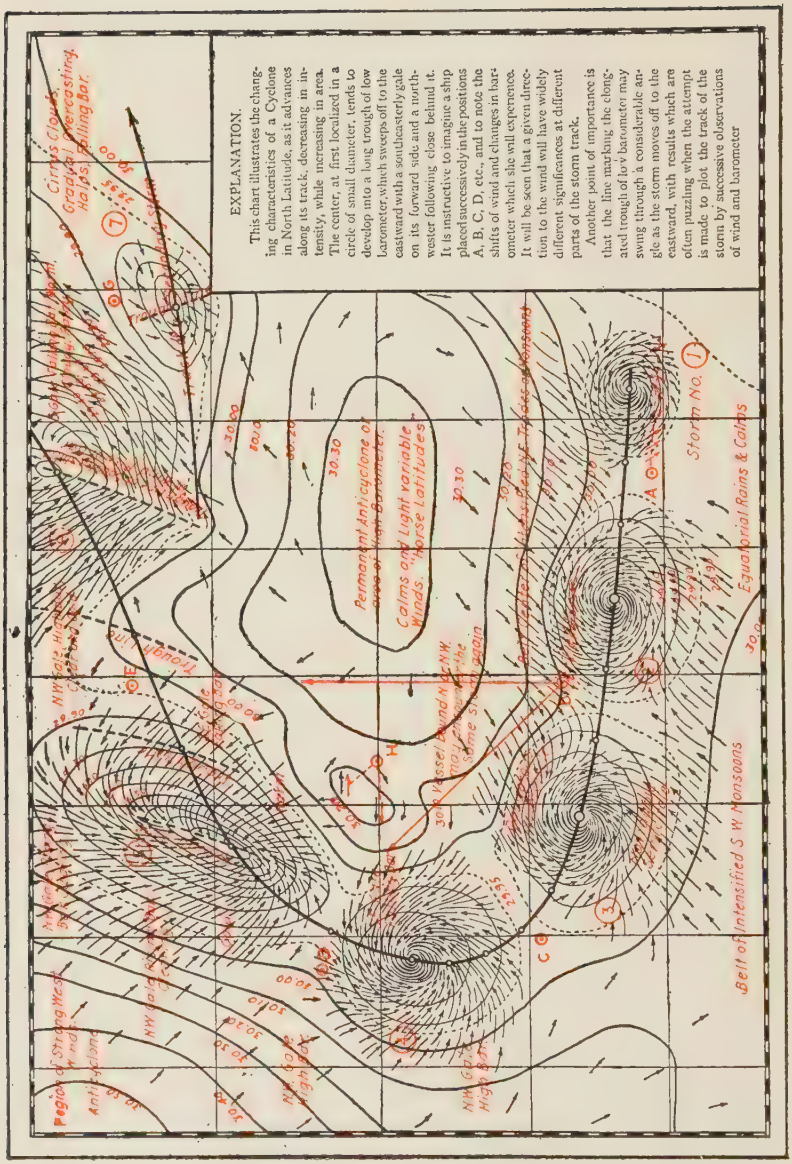
At the request of the Naval Academy authorities the following text from the eighth edition of *Knight's Seamanship* has been retained from the old Chapter XIX on "Weather and the Law of Storms" and has been inserted in this Appendix.

Indications of the Approach of a Hurricane.

Earliest indications.—The distant storm usually causes an abnormal *rise* of the barometer, with cool, dry, fresh winds and cessation or reversal of the ordinary land and sea breezes, with a very transparent atmosphere. A long low swell is often noticed at a great distance, sometimes hundreds of miles, with occasional high hurricane rollers. The direction of the swell, when unaffected by intervening islands and neighboring coasts, indicates the bearing of the center; as do also the light feathery plumes of cirrus cloud that radiate from a point of the horizon marked by a whitish arc.

Unmistakable signs.—As the sky becomes hazy with a thin uniform cirrus veil, halos are noticed by day and night, the barometer begins to fall slowly, the air becomes heavy, hot and moist, with red and violet tints at dawn and sunset; the low but solid and rugged looking cloud-bank of the hurricane appears on the horizon like distant land; squalls break off and diverge from it, and later squalls are noticed passing across the line of bearing of the center of the bank. Fine misty rain forms, seeming to grow out of the atmosphere; a heavy cross sea is felt, and the barometer, while falling rapidly, becomes unsteady.

A vessel situated in front of and near the path of a cyclonic storm will commonly experience a long, heavy swell, a falling barometer with heavy rain, and increasing winds, the direction and changes of which will depend upon her position with reference to the center and the track. A comparison of the three positions of a storm plotted in Plate **201** will show that whereas in Fig. 1, a wind from N.E. or E.N.E. marks a position near


EXPLANATION.
This chart illustrates the changing characteristics of a Cyclone in North Latitude, as it advances along its track, decreasing in intensity, while increasing in area. The center, at first localized in a circle of small diameter, tends to develop into a long trough of low barometer, which sweeps off to the eastward with a southeasterly gale on its forward side and a northwester following close behind it. It is instructive to imagine a ship placed successively in the positions A, B, C, D, etc., and to note the shifts of wind and changes in barometer which she will experience. It will be seen that a given direction to the wind will have widely different significances at different parts of the storm track.
Another point of importance is that the line marking the elongated trough of low barometer may swing through a considerable angle as the storm moves off to the eastward, with results which are often puzzling when the attempt is made to plot the track of the storm by successive observations of wind and barometer
Cirrus Clouds
Gradual overcasting.
Halo
Falling Bar.
Permanent Anticyclone of area of High Barometer.
Calms and Light variable Winds, Horse Latitudes
Storm No. 1
Equatorial Rains & Calms
Belt of Intensified S.W. Monsoons
Region of strong Westerly winds and Anticyclones

OCEAN CYCLONES AND ANTI-CYCLONES OF THE NORTHERN HEMISPHERE.

A Diagram of Typical Wind Circulation from Anti-cyclones to and around Cyclonic Storm Centers in Oceans North of the Equator, and the Tracks along which Storms Usually Move.

Fig. 3.

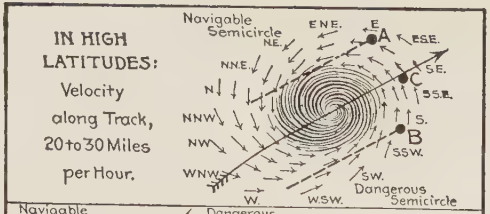


Fig. 2.

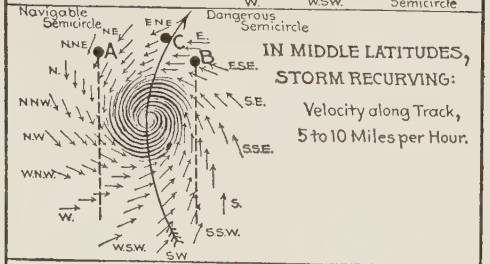
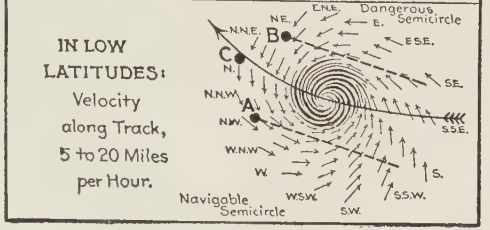


Fig. 1.



Northern Hemisphere.

Fig. 4

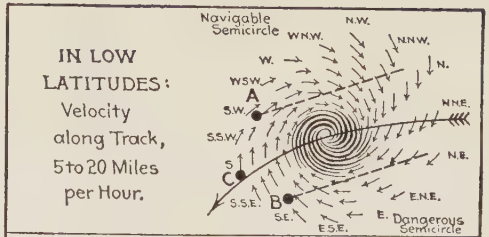


Fig. 5.

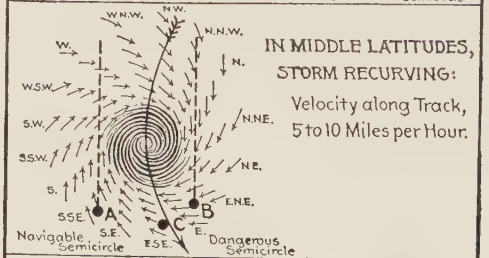
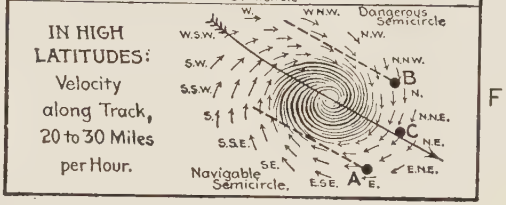


Fig. 6.



Southern Hemisphere.

A HURRICANE RECURVING.

E, in the forward right-hand quadrant (the most dangerous part of the storm), in Fig. 3, the same direction of the wind marks a position near A in the navigable semi-circle and clear of all real danger; while in Fig. 2, it marks a position near C, almost in the track of the storm. This shows the importance of considering the ship's position as to latitude and longitude, in connection with other data; but in attempting to draw conclusions from this it must not be forgotten that the latitude of recurving can be known only in a very general way.

Rules for Manœuvring.

The rules for manœuvring with reference to a storm have for their objects: 1st, to determine the bearing and distance of the center and the track along which it is moving; 2nd, to avoid the center and, if possible, to keep out of or escape from the dangerous semi-circle; 3d, to ride out the storm in safety if unable to escape from it.

It has been shown that the bearing of the center may in some cases be determined, while the storm is at a distance, by observations of the cloud-bank and especially of the point from which the cirrus plumes are seen to radiate; and in some cases, also, by the direction of the long swell which often precedes the storm. But these indications are confined to the early stages of the storm's advance, within the limits of the tropics. Under other circumstances, the only indications of value are the direction and force of the wind and the action of the barometer. The old rule for determining the bearing of the center was to assume it as eight points from the direction of the wind; to the right in the northern hemisphere and to the left in the southern. It is now known that this eight-point rule is true only near the center of the storm, and that near the edge, the center may bear as much as twelve points from the wind.

The following perhaps expresses as definitely as a rule can express it, this relation between the direction of the wind and the bearing of the center of the storm.

Rule.—*When the approach of a revolving storm is first clearly recognized, the bearing of the center may be assumed as between 10 and 12 points from the direction of the wind. When the characteristic features of the storm are fully developed, the wind having the force of a gale and the barometer falling steadily, the bear-*

ing may be assumed as between eight and ten points. As the storm continues to increase and after the barometer has fallen as much as half an inch, the bearing may be taken as about eight points.

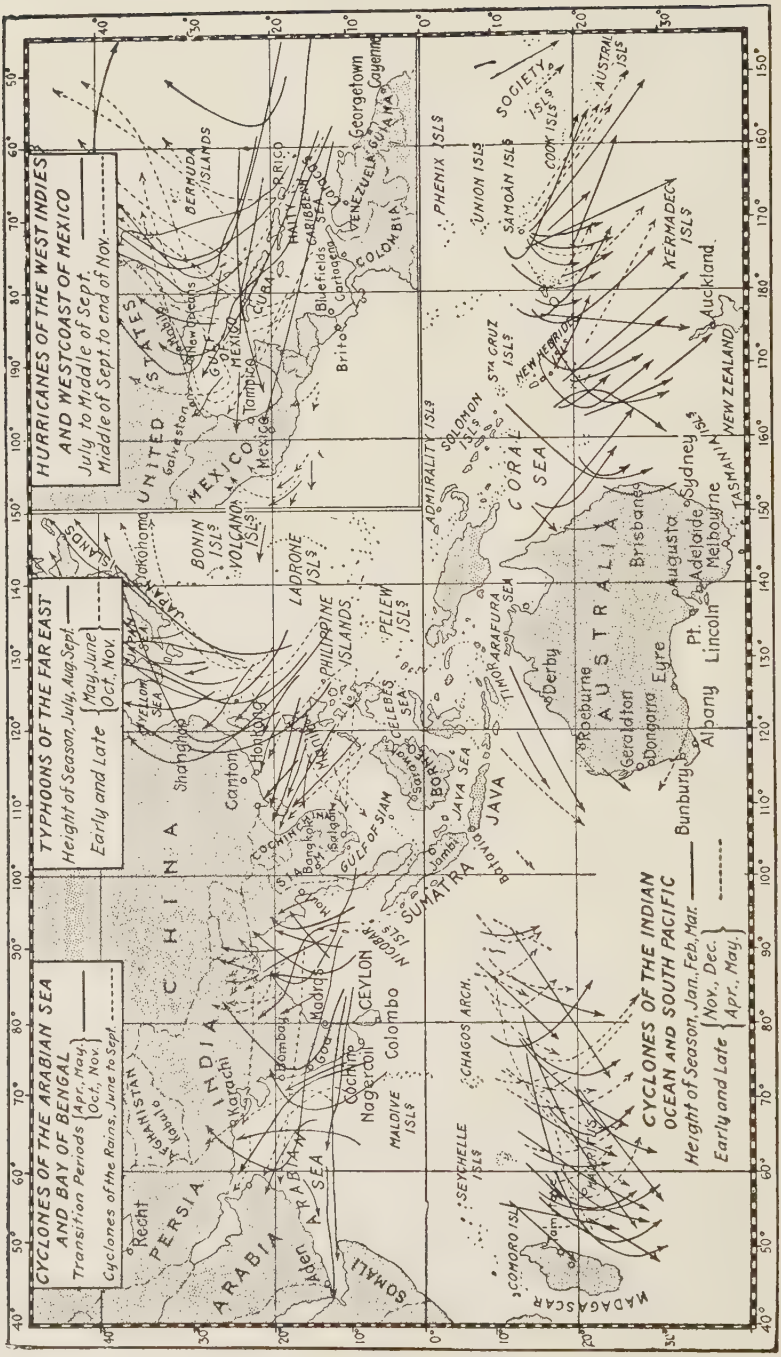
It will be understood that neither this rule nor any other one can take the place of an intelligent comprehension and application of the principles which have been explained in the preceding pages.

For data as to the path of the storm, a vessel must heave-to and note the changes in the bearing of the center, and the fall of the barometer.

Plate **200** shows the changes in conditions which would be noted by vessels over which the storm is passing along the different lines there indicated. The hauling of the wind to the right indicates that the vessel is in the right-hand semi-circle; hauling to the left, that she is in the left-hand semi-circle.

This rule holds for both hemispheres; but whereas in the northern hemisphere the dangerous semi-circle is to the right, in the southern hemisphere it is to the left. In either hemisphere, if the wind continues from the same direction with a steadily falling barometer, the chances are that the ship is in the track of the storm. One important exception should, however, be noted. When a hurricane moves along the edge of a trade-wind or monsoon region, the prevailing winds are intensified over a wide area, without appreciable change in direction, giving rise to what are known as "intensified" trades or monsoons. These are illustrated in Fig. 1, Plate **203**. In this figure, a vessel at A, hove-to, would have a falling barometer, and no change in the direction of the wind. But if she infers that she is directly in front of the center, and runs before the wind, she plunges directly into the vortex. The only safe course under these conditions is to haul off to the right (in the particular case illustrated in the figure), carrying all the sail that is safe and gaining as much ground to that side as is possible before it becomes necessary to lie-to. *It must be remembered that this applies only to the exceptional case of a hurricane encountered on the border of a trade-wind or monsoon belt.*

It is not a matter of indifference on which tack a ship heaves-to while watching the wind, barometer, and clouds, and waiting for the situation to declare itself. Consider, for example, the ships of Fig. 2, Plate **203**. If the ship B, in the right-hand


CYCLONES OF THE ARABIAN SEA AND BAY OF BENGAL
Transition Periods {Apr., May. / Oct., Nov.
Cyclones of the Rains, June to Sept.
TYPHOONS OF THE FAR EAST
Height of Season, July, Aug. Sept.
Early and Late {May, June / Oct., Nov.
HURRICANES OF THE WEST INDIES AND WESTCOAST OF MEXICO
July to Middle of Sept.
Middle of Sept. to end of Nov.
CYCLONES OF THE INDIAN OCEAN AND SOUTH PACIFIC
Height of Season, Jan., Feb., Mar.
Early and Late {Nov., Dec. / Apr., May.
STORM TRACKS
CHINA
INDIA
ARABIA
PERSIA
AUSTRALIA
CORAL SEA
UNITED STATES
MEXICO
JAPAN
Yokohama
Shanghai
Canton
Hongkong
Manila
Bangkok
Saigon
Singapore
Karachi
Bombay
Madras
Cochin
Nagercoil
Colombo
CEYLON
Calcutta
Rangoon
Akyab
Chittagong
Cape Recht
Aden
Muscat
Mekran
BALUCHISTAN
ARABIAN SEA
BAY OF BENGAL
GULF OF SIAM
SUMATRA
JAVA
BORNEO
CELEBES SEA
JAVA SEA
TIMOR SEA
ARAFURA SEA
Batavia
Samarang
Soerabaya
Derby
Roeburne
Geraldton
Bunbury
Albany
Eyre
Augusta
Pt. Lincoln
Adelaide
Melbourne
Brisbane
Bongara
Sydney
TASMAN
NEW ZEALAND
Auckland
Wellington
Christchurch
Dunedin
Invercargill
NEW HEBRIDES
SOLOMON ISLS
ADMIRALTY ISLS
BONIN ISLS
VOLCANO ISLS
LADRONE ISLS
PELEW ISLS
PHILIPPINE ISLANDS
PHENIX ISLS
UNION ISLS
SAMOAN ISLS
STA CRUZ ISLS
SOCIETY ISLS
COOK ISLS
AUSTRAL ISLS
KERMADEC ISLS
CHAGOS ARCH.
SEYCHELLE ISLS
COMORO ISLS
MADAGASCAR
MAURITIUS
REUNION
SOMALI
Galveston
New Orleans
Tampico
Mexico
Bermuda Islands
Bluefields
Cartagena
Britol
Georgetown
Cayenne
VENEZUELA
GUIANA
COLOMBIA
HAITI
PORTO RICO
CUBA
CARIBBEAN SEA
GULF OF MEXICO

semi-circle, heaves-to on the starboard tack, the wind and sea will gradually draw aft. If she heaves-to on the port tack, they will draw ahead and she is liable to be taken aback, perhaps in a sudden and violent squall. In the left-hand semi-circle, the conditions are reversed; but here the danger is not in any case as great as in the other semi-circle. The rule is, therefore, in the northern hemisphere, to heave-to *in the beginning* on the starboard tack. If the wind shifts to the right, you are in the dangerous semi-circle and are on the proper tack. If circumstances admit, you may try to work away from the track of the center, close-hauled on the starboard tack. When obliged to lie-to, do so on the same tack.

If, being hove-to on the starboard tack, the wind hauls to the left (ahead), you are in the left-hand or manageable semi-circle, say at A, and heading away from the track of the center. Here you should bring the wind on the starboard quarter and run as long as possible. If obliged to lie-to, do so on the port tack, being careful to make as little headway as possible.

If, the ship being hove-to, the wind remains steady in direction and the barometer continues to fall, it may be assumed, except in the one case which has been discussed above, that the ship is in or near the path of the storm;—say at C. She should run with the wind on the starboard quarter and hold the compass course thus fixed until the barometer begins to rise.

Most of the above rules are reversed for the southern hemisphere. They are summarized for both hemispheres in the following table:

NORTHERN HEMISPHERE.

Heave-to on **Starboard Tack** to note Shift of Wind.

Wind hauls to right	Ship is in right semi-circle DANGEROUS.	Run close hauled on starboard tack. When obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle Manageable.	Run with wind on starboard quarter. If obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on starboard quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

SOUTHERN HEMISPHERE.

Heave-to on **Port Tack** to note Shift of Wind.

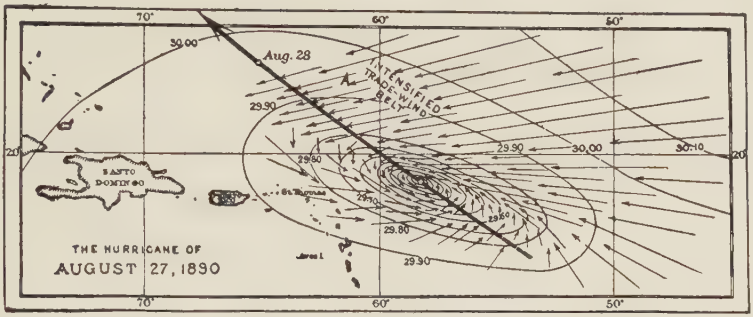
Wind hauls to right	Ship is in right semi-circle Manageable.	Run with wind on port quarter. If obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle DANGEROUS.	Run close hauled on port tack. When obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on port-quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

For plotting the position of the ship within the storm from time to time it is convenient to construct a storm-card like Fig. 2, Plate **203**. This should be on tracing cloth and on a good scale. The ship is then drawn on a sheet of paper and the storm-card moved over it in accordance with the motion of the center as determined from the successive observations made as above described. A rough estimate may generally be made of the distance of the center, from the character of the weather, the force of the wind, the fall of the barometer, etc.

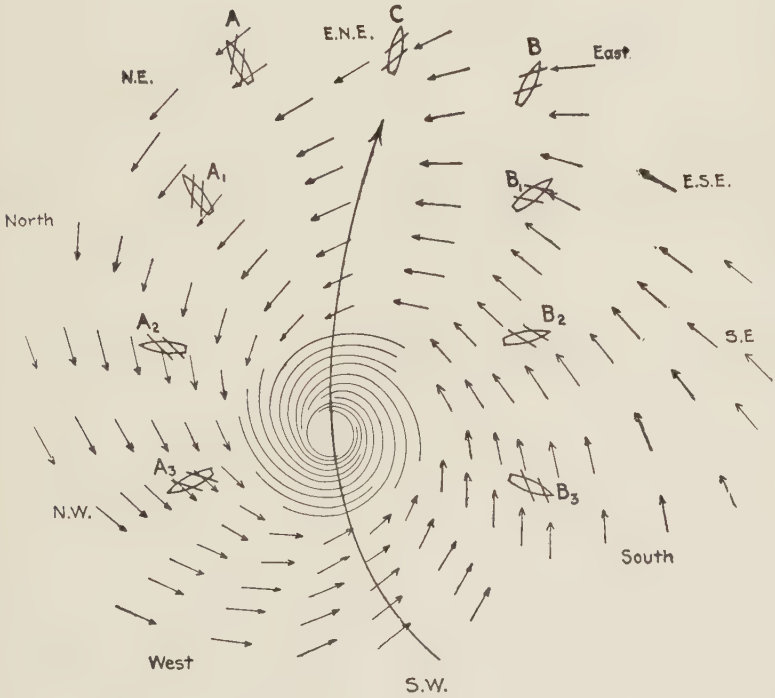
It is hardly necessary to say that circumstances may require the modification of the foregoing rules in many directions. One of the most frequent reasons for such modifications is the proximity to land. The influence of this point upon the course to be adopted will be greatly affected by the way in which it is known that the wind will shift. There is less danger in closing with a coast if it is certain that the shifts of wind will be offshore and not on. So with regard to seeking an anchorage. It may be safe to anchor in an open roadstead if the shifts of wind are bound to be such as to give a lee; it would be hazardous to anchor if the reverse were the case.

Naturally, also, the seaworthiness of the ship, her speed, and many other conditions, are factors in the problem of manœuvring.

The latitude in which the storm is encountered makes a difference because of the difference in intensity; and a vessel may



Example of Intensified Trade-Wind Belt.



A Cyclone in the Northern Hemisphere.

SHIFTS OF WIND IN A CYCLONE.

safely hold her course through a storm in the North Atlantic which she would take every means to avoid in the tropics. On the other hand, it is easier to avoid a storm in the tropics than in high latitudes, because of the difference in the area which it covers. The diameter of a hurricane in the tropics rarely exceeds 300 miles, while in high latitudes it may be a thousand miles or more.

The curvature of the track must be taken into consideration. Vessels have been known to escape from a slow-moving hurricane toward the concave side of the track, only to run into it again after it had recurved.

The preceding directions have especial reference to sailing vessels, but in their general principles they are perfectly applicable to steamers. There is, however, this important difference to be noted; that as a steamer is not dependent for her course upon the direction of the wind, she is much freer to manœuvre and may almost always, unless in the neighborhood of land, keep far enough from the center of the storm to avoid all serious danger. This, however, is true only when the storm is of comparatively limited area and with a center clearly defined; as in positions 1, 2, 3 and 4, of Plate **200**. It is evident that when the storm has spread out over thousands of miles, as in positions 5 and 6, with an elongated trough of low pressure in place of a sharply-defined center, it is hopeless **for even a** steamer to attempt to avoid it. In such a gale, **the directions** suggested in the Chapter (Handling a Steamer in Heavy Weather) become important; and if applied with some reference to the changes in weather which may be anticipated from a study of Plate **200**, they furnish all the directions which should be needed to carry a steamer through any gale in which she has a fair amount of sea-room.

Another point of difference between a steamer and a sailing vessel has to do with the rule for lying-to in the manageable semi-circle. The rule for a sailing ship is to lie-to on the "coming-up" tack in spite of the fact that this brings her head toward the center. For a steamer, the rule in general is to lie-to always with the head away from the center, in order that such headway as is made may be all in the direction of safety.

The Pilot Charts of the North Atlantic and North Pacific

Oceans, issued by the Hydrographic Office of the United States Navy Department, should be familiar to all mariners. These are in substance Monthly Weather Maps of the Ocean and contain a large amount of valuable information not elsewhere to be found, upon a great variety of topics.

§ 7. STORM SIGNALS

Disturbances, Storms, and Hurricanes. Storms of tropical and subtropical areas of the southern North Atlantic Ocean, including the Gulf of Mexico and Caribbean Sea, are referred to in advices and warnings of the Weather Bureau as tropical disturbances, or hurricanes, depending upon the intensity, as indicated in the reports received by the Bureau. If reports do not indicate winds of destructive force or abnormally low barometric pressure at the center, they usually describe it as a tropical disturbance of slight or moderate intensity. The term "hurricane" is used when it is apparent that the storm is one of marked intensity, accompanied by destructive winds. The language in all advices and warnings is intended to describe the intensity of the storm as accurately as available information permits.

Information on Which Warnings and Advices Are Based. During the hurricane season the Weather Bureau secures by telegraph, cable, and radio, twice-daily reports from numerous coastal and island stations in the areas frequented by these storms, and special observations are secured at intervening hours when required. In addition, the Bureau maintains an extensive weather-reporting service on ships at sea, from which twice-daily reports are received by radio. When a tropical storm is in progress, requests for special observations are broadcast to all ships in the general area in which the storm is located. Every available agency is used in the fullest possible manner to secure information with the greatest dispatch.

Storm Warnings. The first warnings issued in connection with a tropical disturbance are usually storm warnings. They contain information as to the location, intensity, and direction of movement of the disturbance and indicate that persons in the areas in which storm warnings are specified are likely to experience at least winds of considerable force on the outer edge of the storm.

As long as the disturbance is still some distance at sea, display of storm warnings indicates that there is a *possibility* that the storm center may later approach closely to any part of the area covered by the storm-warning display, with resultant winds of great violence.

Hurricane Warnings. As soon as it becomes evident that the storm center will reach a certain section of the coast line, hurricane warnings are hoisted over a comparatively restricted area in which winds of hurricane force are expected to prevail. Hurricane warnings are given immediate distribution by every means available to the Weather Bureau and through numerous agencies that assist the Bureau in such emergencies.

Display of Flags and Lanterns. To indicate the approach of storm or hurricane winds, the Weather Bureau displays at some 380 stations on the Atlantic, Gulf, and Pacific coasts of the United States, and on the Great Lakes, flags by day and lanterns by night as a warning. Description of these displays and their meanings follow (See Plate No. **204**):

The Small Craft Warning: A red pennant indicates that moderately strong winds that will interfere with the safe operation of small craft are expected. No night display of small craft warnings is made.

The Northeast Storm Warning: A red pennant *above* a square red flag with black center displayed by day, or two red lanterns, one above the other, displayed by night, indicates the approach of a storm of marked violence with winds beginning from the *northeast.*

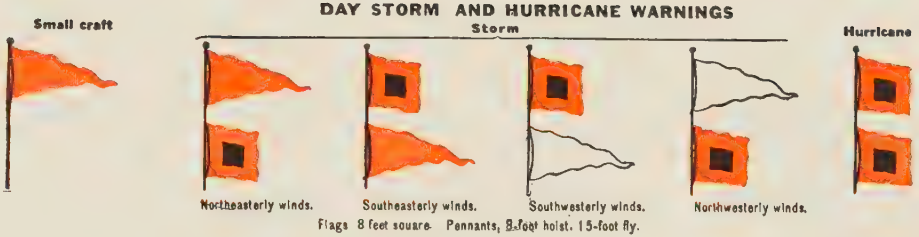
The Southeast Storm Warning: A red pennant *below* a square red flag with black center displayed by day, or one red lantern displayed by night, indicates the approach of a storm of marked violence with winds beginning from the *southeast.*

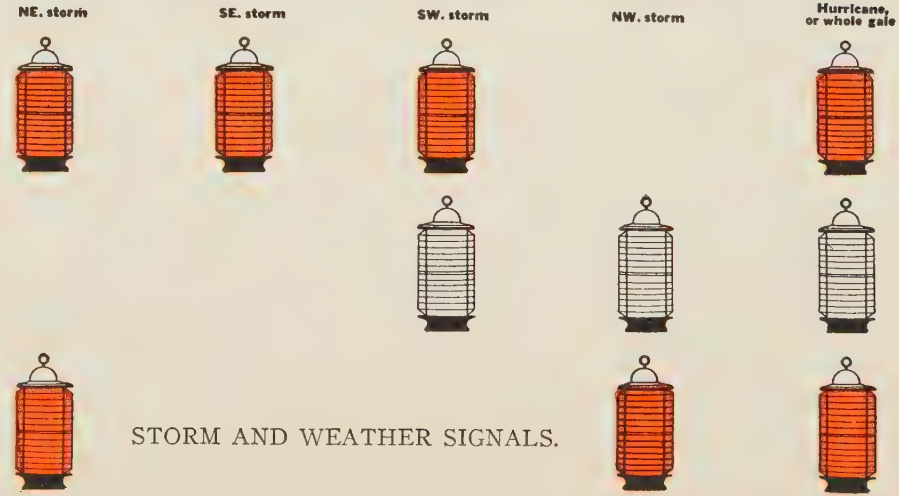
The Southwest Storm Warning: A white pennant *below* a square red flag with black center displayed by day, or a white lantern *below* a red lantern displayed by night, indicates the approach of a storm of marked violence with winds beginning from the *southwest.*

The Northwest Storm Warning: A white pennant *above* a square red flag with black center displayed by day, or a white lantern *above* a red lantern displayed by night, indicates the ap-

proach of a storm of marked violence with winds beginning from the *northwest.*

Hurricane, or Whole Gale Warning: Two square flags, red with black centers, one above the other, displayed by day, or two red lanterns, with a white lantern between, displayed by night, indicate the approach of a tropical hurricane or of one of the extremely severe and dangerous storms which occasionally move across the Great Lakes.





STORM AND WEATHER SIGNALS.

Plate No. 204

NAVAL TERMS AND DEFINITIONS.

Aback. Set of a ship's sails when the wind acts upon them in a direction that has a tendency to force the ship astern.

Abaft. A relative term used to describe the location of one object in relation to another, in which the object described is farther aft than the other. Thus: the mainmast is abaft the foremast.

Abaft the Beam. Said of the bearing of an object which bears between the beam and the stern.

Abandon. For all hands to leave —as abandon ship.

Abeam. The bearing of an object 90 degrees from ahead.

Aboard. In the vessel.

About. On the other tack.

Aboveboard. Above decks. Without concealment or deceit.

Abreast. Abeam of.

Accommodation Ladder. The portable steps from the gangway down to the water-line.

Adrift. Loose from the moorings.

Advance. The distance a vessel travels toward the original front in turning.

Aerostat. An aircraft whose support is chiefly due to buoyancy, its interior being occupied in the main by one or more bags or cells filled with gas lighter than the surrounding air; same as lighter than air craft.

Afloat. Resting on the water.

Aft. At, near or toward the stern.

After Bow Spring. A bow spring leading aft, checking a vessel from going ahead; generally used in mooring or docking.

After Brow. The brow thrown over aft.

After Quarter Spring. A spring from the quarter leading aft, checking a vessel from going ahead; generally used in mooring or docking.

After Sails. The sails bent to the masts abaft the foremast.

After Waist Spring. A spring from amidships leading aft, checking a vessel from going ahead; sometimes used in mooring or docking.

Against the Sun. From right to left; used in laying up rope or coiling it down.

Aground. Resting on the bottom.

Ahoy. A term used in hailing a vessel or boat.

Air Tank. A metal air-tight tank built into a boat to ensure flotation when boat is swamped.

Alee. To the leeward side.

Alive. Alert.

All-hands. The entire crew.

All in the Wind. When all the sails are shaking by being too close to the wind.

All Night In. Having no night watches.

All Standing. (1) To bring to a sudden stop. (2) To turn in with all ones clothes on. (3) Fully equipped.

Aloft. Above the upper deck.

Alongside. Side to side.

Altar. A step of a dry dock.

Alto-Cumulus. Clouds of the third highest level and forming large globular masses.

Alto-Stratus. Clouds forming a thick grayish or bluish sheet.

Amain. All at once. On the run.

Amidships. In or towards the middle of a ship in regard to length or breadth.

Anchor. A device of iron so shaped as to grip the bottom and hold a vessel at anchor by the anchor chain.

Anchorage. A place suitable for anchoring.

Anchor Bar. A wooden bar with an iron shod wedge-shaped end, used in prying the anchor or working the anchor chain.

Anchor Chain. Heavy studlinked chain secured to an anchor for mooring or anchoring.

Anchor Hoy. A lighter with a derrick for handling heavy anchors.

Anchor Lights. The riding lights required to be carried by vessels at anchor.

Anchor's Aweigh. Said of the anchor when just clear of the bottom.

Anchor-watch. A detail on deck at night when at anchor, to safeguard the vessel.

Anemometer. An instrument for measuring wind velocity.

Aneroid Barometer. A mechanical barometer containing no liquid.

Angle Bar. Used to form the inboard side of a waterway. Also used in the construction of framing of a vessel.

Annunciator. (1) An electric drop indicating the source of a call. (2) A signal device used to send orders to engine and fire-rooms.

Anti-cyclone. An outflowing spiral eddy of wind.

Apeak. In a vertical line. Said of an anchor when hove in so the chain leads up and down, and of yards and oars when vertical or nearly so.

Arched Squall. A squall higher in the center than on the sides.

Ardent. Said of a sailing craft which requires weather helm to prevent her from flying up into the wind.

Arm. The elbow at the lower end of the shank and terminating in the fluke of the anchor.

Arming. The tallow placed in the cavity at the bottom of a lead for the purpose of bringing up a sample of the bottom.

Armor Belt. The width of armor carried on a man-of-war above and below the water-line.

Armor Shelf. The plate forming the foundation for the armor belt.

Ash Breeze. No wind, requiring a sailing vessel to resort to the use of oars.

Ashore. On the shore.

Astern. The bearing of an object 180 degrees from ahead.

Athwart-hawse. Across a vessel's cable or stem.

Athwartships. At right angles to the fore-and-aft line of the vessel.

Atlantis, Lost. A supposedly sunken continent in the Atlantic Ocean.

Atoll. A small circular island, usually of coral, enclosing a lagoon.

Atrip. Said of an anchor when it clears the bottom in heaving in.

Avast. An order to stop or cease hauling.

Awash. Level with the water.

A-weather. To windward.

Aweigh. Off the bottom; said of an anchor.

Awning. A canvas canopy secured over a ship's deck as a protection from the weather.

Aye Aye, Sir. The reply to an officer's order signifying that it is understood and will be obeyed.

Back. Said of the wind when it shifts counter-clockwise. To set up a preventer, such as an extra anchor.

Backboard. A rest for the steersman's back, consisting of an athwartship vertical board.

Backbone. The rope stitched to the back of the middle of an awn-

ing and to which the crow's foot is spliced.

Backstay. A rope bracing a mast from aft and leading from the mast-head to the rail.

Back Wash. The agitated water thrown aft by the propellor.

Baffling Winds. Shifting light airs.

Bag. Sails setting too full, with slack canvas and taut leeches.

Bail. To throw water out of a boat; a yoke, as a ladder bail.

Balanced Rudder. A rudder, a part of whose area is forward of the axis of rotation.

Balancing Ring. The ring fitted at the balancing point on the shank of an old-fashioned anchor for fishing the anchor.

Baldheaded Schooner. A schooner without topsails.

Bale. A tightly packed bundle.

Bale Sling. A strap for slinging sacks and barrels.

Ball. The extremity of the end of the stock of an old-fashioned anchor.

Ballast. Heavy weights packed in the bottom of a boat or ship to give her stability.

Ballast Tanks. Double bottoms for carrying water ballast and capable of being flooded or pumped out at will.

Balloon Jib. A large full headsail used on yachts off the wind or with wind abeam.

Balsa. A life raft consisting of a wooden grating surrounded by a ring of balsa wood.

Bank. A large shoal. The side of a river. Fires are banked in a boiler when partially smothered with excess coal and drafts closed.

Bare Poles. When no sails whatsoever are set.

Barge. A ship's boat designated for the use of flag officers.

Bark. A three-masted sailing vessel, square-rigged on the fore and main and fore-and-aft rigged on the mizzen.

Bar Keel. An external keel of heavy iron or steel bars.

Barkentine. A three-masted sailing vessel, square-rigged on the fore and fore-and-aft rigged on the main and mizzen.

Barnacle. Small shellfish found on the bottoms of vessels and on underwater parts of docks.

Barometer. An instrument registering the pressure of the atmosphere.

Barometric Gradient. The amount of difference in the readings of a barometer for a given distance perpendicular to the isobars.

Barometric Pressure. The atmospheric pressure as registered by the barometer.

Barratry. Dishonest actions on the part of a shipmaster; applying specifically to the unauthorized sale of the ship by the master.

Barrel. The rotating drum of a windlass, capstan, or winch.

Barrier Reef. Above-water reefs forming protected smooth water inside.

Batten Down. To make water tight, said of hatches and cargo.

Battens. Thin strips of wood fitted into pockets in the leach of a fore-and-aft sail for stiffening the leach. Strips of iron fitting over staples in hatch coamings for securing tarpaulins. Planks along the inner ship's side to protect the cargo from moisture.

Battle Port. A metal hinged port fitted on the inner side of an airport in naval vessels for the exclusion of light and for additional water tight protection.

Beachcomber. A derelict seaman found unemployed on the waterfront, especially in foreign countries.

Beacon. A navigational mark placed on or near a danger.

Beam-ends. Said of a vessel when she is hove over or listed until her deck beams approach the vertical.

Beam Sea. A sea at right angles to a vessel's course.

Beam Wind. A wind at right angles to a vessel's course.

Bear a Hand. To hurry.

Bear Down. To approach from windward.

Bear In. To approach the shore or other object.

Bearing. The direction of an object.

Bear Off. To steer away from shore or another object.

Bear Up. To put the helm up and let the boat run off to leeward.

Beating to Windward. (1) Making progress against the direction of the wind when sailing on the wind or close hauled. (2) Sailing to windward by zigzag tacks.

Becalmed. A sailing vessel dead in the water due to lack of wind.

Becket. A rope eye for the hook of a block. A rope grommet used in place of a rowlock. Also a small piece of rope with an eye in each end to hold the foot of a sprit to the mast. In general, any small rope or strap used as a handle.

Becket Bend. See text.

Becket Rowlock. A rowlock formed of a rope grommet secured over a thole-pin in a sailing launch.

Bed. A resting place.

Belay. (1) To make fast to a pin or cleat. (2) To rescind an order.

Belaying Pin. A wooden or iron pin fitting into a rail upon which to secure ropes.

Bell Buoy. A buoy fitted with a bell actuated by the sea.

Bell Pull. The handle in the steering station by which the engine-room is signalled to by bells, indicating the desired speed.

Belly. Said of a sail when swelled out by the wind.

Belly Strap. A rope passed around a boat for hanging a kedge anchor in carrying out the anchor.

Below. Beneath the deck.

Bend. (1) To make fast, e.g.: bend a cable is to make it fast to the anchor. (2) A knot by which a rope is made fast to another.

Bending Shackle. A shackle placed with the bowed end aft and connecting the chain cable to the ring of the anchor.

Berth. A vessel's place at anchor or at a dock.

Berth Deck. A name applied to a lower complete deck at or near the water-line on old vessels and used primarily for berthing purposes and not as a gun deck.

Between Decks. The space between decks.

Betwixt Wind and Water. That part of the vessel at or near the waterline.

Bight. Any part of a rope except the end; usually refers to a bend in a rope. A cove.

Bilge. The curved part of a ship's hull where the sides and the flat bottom meet. The greatest diameter of a cask.

Bilge Blocks. The built up wooden blocks at the bottom of a dry dock upon which a vessel's bilge rests when in dock.

Bilge Keel. The keel fitted at the turn of the bilge to check a vessel from rolling.

Bilge Ways. The paths across which the bilge blocks may be hauled in placing them for a vessel about to go into dock.

Bill. The extreme tip of an anchor fluke.

Bill-board. The flat sloping bed for an old-fashioned anchor, just abaft the cat head.

Billet. The place allotted an individual to sleep in. It may also refer to his general duties aboard ship.

Bill of Exchange. A written agreement in which a debtor agrees to pay a creditor a specified sum on a specified date.

Bill of Health. A certificate obtained by a vessel from the health

authorities as to the state of health of the port when the vessel clears.

Bill of Lading. A receipt from a vessel for cargo received.

Binnacle. The stand, usually of brass or composition, in which the compass rests and which contains the compensating magnets.

Binnacle List. A list posted on men-of-war with the names of those excused from duty by the Medical Officer on account of sickness.

Bite. To take hold.

Bitt. To take a turn around the bitts with the cable so that it may be held fast or veered.

Bitter-end. The last part of a rope or the last link in an anchor chain.

Bitts. A pair of vertical wooden or iron heads on board ship, used for securing mooring or towing lines. Similar to dock bollards.

Black Gang. Members of the Engineer's Force.

Blackwall Hitch. See text.

Blade. The flat part of the end of an oar that is thrust into the water when rowing. The back of the palm of an anchor.

Blanket. A vessel is blanketed when another vessel is in such a position to windward as to take the wind out of her sails.

Blinker Tube. A tube carrying a signal light capable of being operated to indicate dots and dashes; the tube directs the beam of light.

Blister. A bulge built into a man-of-war's side as a protection against torpedoes, capable of being flooded or pumped out.

Block. An apparatus consisting of an outside shell and a sheave through which a rope may be passed.

Block-and-Block. Same as two blocks.

Blower. A ventilating or forced draught blower.

Bluff. A full-bowed ship. A steep shore.

Board. A leg.

Boarding Book. A note book on a man-of-war in which an officer boarding another vessel records data obtained.

Boat Boom. The boom swung out from a ship's side when at anchor and to which boats in the water secure.

Boat Cloth. A blue or white cloth thrown over the stern-sheets for officer passengers.

Boat Cover. A canvas cover used to protect a boat when secured in her cradle.

Boat-fall. A purchase of two blocks and a length of rope for hoisting a boat to its davits.

Boathook. A wooden staff with a metal hook at one end used for fending off or holding on.

Boat Number. The number used to designate a ship's boat; boats have two kinds of numbers—the Bureau number carved in the boat, and the ship's boat number to designate a certain boat.

Boat Recall. A signal from a ship to recall a certain boat.

Bos'n's-chair. The piece of board on which a man working aloft is swung.

Boatswain's Chest. The deck chest in which the Boatswain keeps his deck gear.

Boatswain's Locker. The locker in which the Boatswain keeps his deck gear.

Boatswain's Pipe. A small shrill whistle used by the Boatswain's mate in passing a call or in piping the side.

Boat the Oars. The order to place the oars in the boat.

Bobstay. A rope or chain preventing the bowsprit from jumping, and leading from the end of the bowsprit to the vessel's stem.

Bollard. An upright wooden or iron post on dock to which hawsers may be secured.

Bolt. A roll of canvas.

Bolt-rope. The rope around the edge of a sail and to which the sail is sewed.

Bone. Froth at the stem caused by a vessel's way.

Booby Hatch. A wooden hood covering a small after hatchway on board ship.

Boom. A spar used for extending the foot of a fore-and-aft sail. A line of logs secured together to obstruct passage of boats. See boat-boom; cargo-boom.

Boom Cradle. A rest for a cargo boom when lowered to the deck for securing for sea.

Boot. A recruit.

Boot-topping. The anti-corrosive paint used on and above the waterline.

Boss. The rounded hub of the propeller. The rounded section of the stern of a vessel surrounding the propeller shaft.

Bottom Plating. The plating on a vessel's bottom.

Bow. The forward part of a vessel's sides.

Bow Breast. A breast line from forward keeping the bow in to the dock; always used in mooring or docking.

Bow Breast Mooring. A chain offshore mooring leading as a breast from forward to anchor; used for permanent moorings.

Bow Chock. A chock fitted in the bow of a vessel.

Bower Anchor. An anchor carried on each side of the stem.

Bow Line. A mooring or docking line led forward through a bow chock and making a less angle than 45 degrees with the fore-and-aft line of the vessel.

Bowline. See text.

Bowline on a Bight. See text.

Bow Mooring. A chain offshore mooring leading forward from the bow to an anchor; used for permanent moorings.

Bow Painter. The rope secured in the bow of a boat used for securing the boat.

Bowse. To haul in and down on a tackle.

Bowsprit. A spar extending forward from the stem and carrying the lead of part of the gear for the head sails.

Boxing Off. A term used when a vessel's head is paid off after missing stays.

Boxing the Compass. Calling names of the 32 points of the compass in order.

Brails. Ropes used for furling fore-and-aft sails such as the spanker into the mast. They may be foot, throat or peak brails.

Break. The break of the forecastle or the poop is the end of the raised deck.

Breaker. A small cask for fresh water carried in ship's boats. Surf.

Break Ground. Said of an anchor when it lifts clear of the bottom.

Break Off. To stop.

Break Out. To unstow.

Breaks. A sea breaks when it curls forward into surf.

Breakwater. A low bulkhead forward to prevent seas from coming aft. A structure such as a sea wall used for breaking the force of waves.

Breast. A mooring or docking line leading at an angle of about 90 degrees with the fore-and-aft line of the vessel. To meet the sea.

Breast-band. The band of canvas lashed in the chains across the breast of the leadsman.

Breast Off. To shove out from a dock or another vessel.

Breach. A clear breach is said of seas that break entirely over a vessel; a clean breach, when a clear breach carries away masts and rails.

Breech. The part of a block opposite to the swallow.

Bridge. The raised platform extending athwartships in the for-

ward part of the ship and from which the ship is steered and navigated. Amidships and after bridges are sometimes fitted.

Bridle. A span of rope with ends secured.

Brig. A two-masted sailing vessel, square-rigged. The ship's prison.

Brigantine. A two-masted sailing vessel, square-rigged on the fore and fore-and-aft rigged on the main; in olden days this type carried a square main topsail.

Bright Woodwork. Woodwork kept scraped and not painted.

Bright Work. Brass work, polished.

Bring To. To heave or lie-to or to come to an anchorage.

Bring Up. To come to a stop. If suddenly, the term is "Bring up all standing."

Broaching To. To fly up into the wind unintentionally; to be thrown broadside on, in surf.

Broad on the Bow. The bearing of an object 45 degrees from ahead.

Broad on the Quarter. The bearing of an object 135 degrees from ahead.

Broadside. The side of a vessel above water. A firing in salvo of all the guns on one side of the ship.

Brow. A portable gang plank.

Brow Landing. A platform extending over the ship's side to support the inboard end of a brow.

Brow Truck. The truck upon which a brow rolls.

Buckler. A plating fitted into a port or hawse pipe, to close it.

Buckling. Bending or working.

Building Slip. The location of the building ways.

Bull's Eye. An oval piece of wood with a hole through it for the lead of a rope.

Bull Rope. A rope working through a bull's eye, especially one used in securing a light yard or mast.

Bull the Buoy. Said of a vessel when her sides bump a buoy.

Bulkhead. Transverse or longitudinal partitions separating portions of the ship.

Bulwarks. The light plating or wooden extension of the ship's sides above the upper deck.

Bumboat. A boat with articles for sale which comes alongside of a vessel in port.

Bumpkin. A short spar extending horizontally out from a ship's sides to give a lead to running or standing rigging.

Bumpkin Shrouds. Ropes of iron securing a bumpkin vertically to the vessel's side.

Bunk. A built-in bed on board ship.

Bunker. A compartment for the stowage of coal.

Bunting. Flag material or flags collectively.

Buoy. Floating beacons.

Burgee. A swallow tailed pennant.

Bushing. The bearing of the sheave of a block on the pin.

Butt. The ends of decks or outside planking where they meet.

Butt End First. Said of a sudden squall of wind striking a vessel after a period of calm.

By the Board. Overboard.

By the Head (Stern). Deeper forward (aft).

By the Run. To let go altogether.

By the Wind. Sailing close to the wind but keeping the sails filled.

Cabin. The captain's quarters. The enclosed space of a decked-over small boat.

Cable. A rope or chain of great strength, generally used in reference to chain or rope bent to the anchors.

Cable-laid. Nine-stranded, left-handed rope, the strands being

made up in three right-handed ropes of three strands each.

Cable-Length. 100 fathoms or 600 feet.

Cable Ship. A vessel fitted and used for handling a submarine cable.

Caisson. The gate to a dry dock, either floating or sliding.

Caisson Disease. The "bends," affecting divers and caused by too sudden changes in pressure.

Calibrate. To measure and adjust the error, especially of radio compasses and gun sights.

Call. The boatswain's pipe.

Call Away. To summon a boat's crew by a boatswain's pipe or bugle to man and prepare their boat for a trip.

Calm. A wind of force less than one knot.

Camber. The difference in horizontal athwartship's level of a vessel's deck, highest on the centre line.

Camel. A wooden float placed between a vessel and a dock and acting as a fender.

Can Buoy. A cylindrical metal buoy.

Can Hooks. Hooks on a bridle for hoisting casks by hooking into chines.

Canopy Cover. A canvas cover secured to frames shipped in the rail of a boat as a protection against the weather.

Cant. To turn a vessel's head, especially in inclosed waters.

Canted. Inclined.

Cap. A wooden block used for holding two spars together, such as the topmast to the lowermast, or the jib-boom to the bowsprit.

Capsize. To overturn.

Capstan. The vertical barrel situated on the forecastle and geared to the windlass.

Capstan-bar. A wooden bar which may be shipped in the capstan head for heaving the capstan around by hand.

Captive-Balloon. A balloon restrained from free flight by means of a cable attaching it to the earth.

Cardinal Points. The four principal points of the compass—North, East, South and West.

Careen. To list or heel over.

Car Float. A lighter fitted with tracks for carrying railroad cars.

Cargo Battens. Planks used to hold cargo away from bulkheads and ships' sides.

Cargo Block. A large metal block used on a cargo boom.

Cargo Boom. A swinging boom plumbing a cargo hatch and used in handling cargo.

Cargo Hatch. A hatch over a cargo hold.

Cargo Light. A group of electric lights under a reflector for working cargo.

Cargo Net. A square rope net for slinging cargo.

Cargo Port. A square side-port for use in loading or discharging cargo.

Carry Away. To break or tear loose.

Cartel. An agreement for an exchange of prisoners; a cartel ship is for the purpose of transporting such persons.

Carvel Built. Constructed with parallel flush outside planking.

Cast. (1) To throw. (2) To turn a vessel's bow in one direction or another, particularly in getting underway.

Cast Off. To let go.

Cast Loose. To let go or unfurl or cast off.

Cat. To heave an anchor up to the cathead and secure it there.

Catamaran. A platform secured to two hollow floats, used as a liferaft or for work alongside a ship.

Cat Block. The lower block of the old type of cat-fall, usually double or three-fold.

Cat Boat. A small sail boat with mast stepped well forward and carrying only a mainsail.

Catch. The point at the beginning of the stroke when the oar takes the water.

Catch a Crab. Immersion of the oar during the recovery thereby causing loss of control of the oar.

Catch a Turn. To take a turn with a rope quickly, usually for holding it temporarily.

Cat Davit. The davit used for the cat fall of an old-fashioned anchor.

Cat Fall. The fall used to cat an old-fashioned anchor.

Cat Head. The timbers projecting horizontally in the bows of a sailing ship and to which an old-fashioned anchor is raised or catted.

Cat's Paw. See text.

Caulk. To fill in the seams with cotton or oakum.

Caulking Mat. A canvas mat used by men-of-war's men when sleeping on the deck.

Caulking Off. Sleeping.

Ceiling. A floor of planks over tank tops.

Center Board. A wooden or metal board carried in a fore-and-aft trunk and capable of being lowered to overcome the leeway of a boat sailing on the wind.

Centering Chains. Hung across a dry dock and carrying a disk to indicate the exact centre of the dock.

Chafe. To wear the surface of a rope or spar by rubbing.

Chafing Gear. A guard of canvas or rope around spars or rigging to take the chafe.

Chafing Mat. A mat woven from strands of old rope and used to prevent chafing.

Chain Hooks. Long metal hooks used in handling chain cable.

Chain Locker. A compartment forward where the chain cable is stowed.

Chain Plates or Channels. Iron or bronze strips bolted to the side of a ship for securing the lower ends of shrouds and stays.

Chains. The station for the leadsman.

Chain Stopper. A short length of chain fitted with a slip hook secured to an eye-bolt on the forecastle for quick releasing of the anchor and chain upon anchoring.

Chain Tierers. Men stationed in the chain locker to stow the chain when heaving in.

Channel Buoy. A buoy marking the sides of a channel.

Charley Noble. The galley smokepipe.

Check. To ease off gradually; to check a line means to keep a strain on it but to slack it as necessary to avoid parting.

Cheek Block. A half shell covering a sheave, the other cheek being the spar to which it is secured.

Cheeks. The sides of a block.

Chine. The part of a cask at the end of the staves.

Chip. To remove rust or paint by the use of small hammers.

Chip Log. A speed measurer used on sailing vessels and consisting of a chip or quadrantal sector of wood weighted and fitted with a bridle and toggle, a log line, and a measuring glass.

Chock. A heavy wooden or metal fitting secured on a deck or on a dock, with jaws, used for the lead of lines or cables.

Chock-a-block. Full; specifically when the two blocks of a tackle have been drawn as close together as possible.

Choked. The falls foul in a block; the falls may be choked intentionally for a temporary securing.

Choke the Luff. To jam a block by placing the end of a rope across the sheave.

Chow. Food.

Circular Storm. A revolving storm.

Cirro-Cumulus. Clouds of the

next to the highest level and forming small globular masses.

Cirro-Pallium. A cirrus veil covering the sky in advance of a storm.

Cirro-Stratus. Clouds forming a thin whitish sheet.

Cirrus. The highest clouds, detached and delicate, in the form of white feathers.

Clamp Down. To sprinkle and swab down, as a deck in hot weather.

Clap On. (1) To seize a rope and haul away. (2) To make more, as clap on sail.

Clapper. The movable wooden piece in the jaws of a gaff to prevent jamming.

Claw Off. Working off a lee shore.

Clean. Said of a vessel with fine lines.

Clear. Leaving port with all formalities concluded. To empty. To work clear, as of a shoal. To untangle.

Clearance. The papers furnished a vessel by port authorities to indicate that regulations have been complied with before leaving.

Clear Hawse. Chain leading clear and directly to the anchors when two anchors are down; the operation of clearing the hawse of turns.

Clear Hawse Pendant. A short piece of open-link chain fitted with a slip or pelican hook and tailed with wire rope; used in clearing hawse.

Clear for Running. Ready to run out without fouling.

Clear View Screen. A device consisting of a glass disk rotated by a motor fitted to a bridge window to throw off rain, snow and spray.

Cleat. A fitting of wood or metal with horns, used for securing lines.

Clew. The after lower corner of a fore-and-aft sail.

Click. A panel in a windlass or capstan to prevent reversal of movement.

Clinch. See text.

Clinker Built. Constructed with over-lapping outside planking.

Clinometer. An instrument for measuring the degree of roll or heel.

Clipper Bow. A stem curving up and forward in a graceful line.

Close-hauled. Sailing close to the wind; same as full-and-by, on the wind, or by the wind.

Close Reefed. A sail is close reefed when it is reduced to the smallest area by the last row of reef points.

Close Winded. Said of a sailing ship which can point close to the wind.

Clothes Stop. Small cotton line used for stopping clothes to the line or for securing clothes rolled up in bags or lockers.

Cloud Bank. A bank of clouds.

Clove Hitch. See text.

Club. A spar spreading the foot of an upper staysail or a club topsail or the foot of the jib.

Club Topsail. A topsail having the luff laced to a sprit and the foot to a club; used in sailing yachts.

Club Topsail Sprit. The spar to which the luff of the club topsail is laced—the spar to which the foot is laced is called a club.

Clump Block. A small oval block with rounded shell used on staysail pendants.

Clump Fitting. A fairlead for the paravane down haul.

Coaming. The raised framework about deck openings, and cockpits of open boats.

Cockbill. (1) To hang an anchor up and down clear of the water. (2) To incline the yards in a vertical direction.

Cockpit. The well of a sailing vessel, especially a small boat, for the wheel and the steersman.

Cod Line. Small stuff made of untarred American hemp or of cotton; used for hammock clews.

Code. A combination of symbols used in transmitting messages.

Cofferdam. The space between two bulkheads set close together, especially between fuel oil tanks.

Coil. To lay down rope in circular turns.

Coir. Rope made of the fibres of cocoanut husks; used for small lines requiring buoyancy.

Cold Wall. The current of cold water flowing southwestward inside of the Gulf Stream.

Collision Bulkhead. A watertight athwartship bulkhead a short distance abaft the stem, for the purpose of confining damage due to a head-on collision.

Collision Mat. A heavy square of canvas hauled under the side to plug a leak or shell-hole.

Colors. The national ensign.

Come Home. Said of an anchor when it drags toward the ship in heaving in.

Come Up (Behind). To slack away after hauling so that the gear may be belayed.

Coming-up Tack. The tack on which a sailing vessel lies to in a circular storm when the change of direction of the wind will keep bringing her up or further to windward of her original compass course.

Commission Pennant. The pennant flown at the main truck of a ship of war in command of a commissioned officer, not a flag officer.

Common Link. The ordinary studded link of a chain cable.

Companion Ladder. A ladder between the quarter-deck and the officers' quarters.

Compass. An instrument for determining courses steered and bearings, by indicating the magnetic or true North and the ship's head.

Compass Card. The pivoted card-board or tinned brass card of a compass carrying the bundles of magnets and marked on the periphery in degrees and quarter points.

Compensate. To correct a compass for magnetic attraction so that the compass will point very nearly to magnetic north.

Composite Built. Constructed with an iron frame and wooden planking.

Compressor. A curved iron bar swivelled to the under side of the deck at a chain-pipe and with an eye on the end for taking a tackle; it is used to snub the chain.

Concluding Line. A small rope rove through the middle of the steps of a Jacob's ladder.

Connecting Shackle. A shackle placed with the bowed end forward and connecting shots of the chain cable.

Conning. Directing the steering by orders to the steersman.

Continental Shelf. The shelf of a continent, specifically off the Atlantic Coast, extending to about the 100 fathom curve.

Controller. A fitting in the eyes over which a chain cable leads, and with a block which may be raised and which holds the cable by holding a link in a groove of the block.

Controlling Depth. The least depth of a channel or anchorage.

Convoy. A merchant vessel or vessels sailing under the escort of a man-of-war.

Coppers. The large kettles made of copper and used for cooking.

Cord. A line formed by several yarns with an extra twist laid up in the opposite direction.

Cordage. A general term for rope of all kinds.

Cork Fender. A fender made of granulated cork and covered by woven tarred stuff.

Correctors. The permanent mag-

nets for correcting semi-circular deviation, the soft iron sphere for correcting quandrantal deviation, the vertical bar for correcting heeling error and the vertical soft iron Flinders bar.

Coston Signals. Colored fireworks sometimes used for signalling purposes.

Counter. The side of a vessel's quarter.

Course. The point of the compass towards which the vessel is steering.

Course Recorder. An electrical apparatus for graphically and automatically registering the course steered.

Cowl. The bell-shaped opening to a ventilator.

Cow's Tail. The frayed or untidy end of a rope.

Coxswain. The enlisted man in charge of a boat and usually serving as steersman.

Coxswain's Box. The space in the stern sheets of a boat for the coxswain.

Cradle. A stowage rest for a ship's boat.

Crane. A derrick used aboard ship for swinging in and out boats and for handling heavy weights.

Cranky. Topheavy.

Cringle. A piece of rope spliced into an eye over a thimble in the bolt of a sail.

Crossing. Standing across another vessel's bows.

Crossing the Line. Crossing the Equator.

Crowd On. To set all sail possible.

Crowfoot. A bridle of several parts for tricing up the ridge rope of an awning by the crowfoot halliards.

Crown. The lowest part of an anchor, between the arms.

Crow's-nest. The platform on the mast for the lookout.

Crutch. The wooden or metal rest for the boom.

Cumulo-Nimbus. Heavy masses of mountain-shaped clouds, known as the thunder cloud.

Cumulus. The next to the lowest clouds, dome shaped on top and horizontal at the base.

Cut-of-the Jib. General appearance of a vessel, sometimes applied to a person.

Cutter. A double-banked square-sterned ship's boat, used for general ship duty. A sloop-rigged deep-keel vessel with a straight stem.

Cut-water. The foremost part of the stem, cutting the water as the vessel forges ahead.

Cyclone. A revolving wind storm of great intensity.

Dan Buoy. A small buoy to mark fishing nets.

Danger Buoy. A buoy marking a danger to navigation.

Dangerous Semi-circle. The semi-circle of a circular storm in which the velocity of rotation is combined with the velocity of translation.

Dash. A long period of light or sound in the Morse Code.

Dasher Block. A small signal halliard block secured at the end of the spanker gaff.

Davit. A curved metal spar fitting in a socket on deck and projecting over the side or stern for hanging a boat or handling weights.

Davit Guy. A light wire rope secured to an eye on the davit head, set up by a lanyard on the rail and used to swing and steady a davit.

Davit Lever. A metal lever fitted at the step of a davit and used to lower and hoist the davit from its step.

Davy Jones' Locker. The bottom of the sea.

Day's Duty. The term applied to a tour of duty on ship board lasting 24 hours.

Day's Work. The navigational

work from noon to noon necessary in determining a ship's position.

Dead Ahead. Directly ahead on the extension of the fore-and-aft line of the ship.

Deaden the Way. To impede a vessel's progress.

Deadeye. A small flat block with three holes, found on the ends of chain plates and for setting up shrouds and stays.

Dead Head. A spar floating partially submerged.

Dead Light. A heavy circular glass lens set flush and permanently into decks or bulkheads for admitting light or permitting observation.

Dead Men. Irish pennants.

Dead Reckoning. A navigator's reckoning with courses steered and distances run independent of sights or bearings.

Dead Reckoning Tracer. An electrical apparatus for tracing a ship's track.

Deadrise. The vertical distance between the keel of a vessel and the turn of the bilge.

Dead Rope. A rope not led through a block or sheave.

Dead Water. The eddy of a vessel's wake under the counter.

Dead Weight (Capacity). The difference between a vessel's light and loaded displacement.

Dead Wood. The triangular shaped pieces forming the connection between the keel and the stem, and the keel and the stern post.

Deck Beam. An athwartship beam supporting a deck.

Deck Chest. A chest secured on top sides for deck gear.

Deck Horse. An athwartships rod for the traveller of a sheet block.

Deck Light. Thick glass in the deck of a vessel for lighting purposes below.

Deck Load. Cargo carried on deck.

Deck Stopper. A rope or wire stopper fitted with a stopper knot or a toggle and with a lanyard for lashing the cable.

Deck Tackle. A heavy double purchase used about the decks.

Deeps. The fathoms of a lead line which are not marked.

Deep Sea Lead. (Pronounced dip-sea). A lead of 50 pounds weight, armed and used with the deep-sea leadline, which is 120 fathoms or more.

Deep Six. A term meaning to dispose of by throwing over the side.

Degree. $\frac{1}{360}$th of a circumference.

Demurrage. The amount of money allowed a vessel per day when detained in port in loading or unloading beyond a limit specified in her charter party.

Depth of Hold. The distance amidships of a cargo vessel from the top of the floor to the top of the upper deck beams.

Derelict. An abandoned vessel at sea.

Devil's Claw. A strong iron hook used as a stopper for chain cable.

Dew Point. The point of saturation of the air and beyond which the air condenses.

Diagonal Built. Constructed without framing and with double planking running at an angle of 45 degrees with the keel.

Diamond Knot. An ornamental knot made by making a double carrick bend and passing the ends around the bight and up through the center of the bend.

Dinghy. A small handy boat issued to certain vessels of the U. S. Navy, single-banked with four oars, fitted with sail of sprit-rig and either 16 feet or 20 feet in length.

Dip. A position of a flag when hoisted part way of the hoist; to lower a flag part way and then hoist it again.

Dip Rope. A length of open-link chain or wire fitted with an eye and shackle and tailed with a manila rope; used in clearing hawse and in mooring, and in rigging a collision mat.

Dismantle. To strip a vessel of her spars and upper masts.

Dismast. To carry away the masts of a vessel.

Displacement. The weight of the water displaced by a vessel.

Distance Signals. Shapes, flags and pennants displayed according to a code and used for signalling when ordinary code flags cannot be made out at the distance required.

Distress Signal. A flag display or a sound, light or radio signal, calling for assistance.

Ditty-bag. A small bag used by men-of-war's men to stow small articles of wearing apparel.

Ditty-box. A small box with a hinged lid used by men-of-war's men for stowing small articles.

Docking Keel. The heavy wooden keels fitted on vessel outboard of the main keel for use in taking the ship's weight when in dock.

Docking Plan. The ship's plan furnishing for docking purposes all necessary information concerning the under-waterhull.

Dodger. A canvas windbreaker.

Dog's Ear. A small bight made in reefing in the leach rope of a sail. A corner of the shark's mouth of an awning.

Dog-vane. Bunting rigged and used to show the direction of the wind.

Dog Watch. One of the two-hour watches from 4 to 8 p.m., from 4 to 6 p.m. is the first dog watch, and from 6 to 8 p.m., the second dog watch.

Doldrums. The belt on each side of the Equator in which little or no wind ordinarily blows.

Dolphin. A cluster of piles for mooring.

Dory. A small flat-bottomed boat, with sharp bow and tapering stern, used by fishermen and is especially seaworthy.

Dot. A short period of light or sound in the Morse Code.

Double-banked. (1) a boat with two men on a thwart, (2) with two men on an oar.

Double Block. A block with two sheaves.

Double Bottoms. Water-tight subdivisions of a man-of-war next to the keel and between the outer bottom and inner bottom.

Double Carrick Bend. See text.

Double Up. To double a vessel's securing lines.

Double Wall and Crown. See text.

Double Wall and Double Crown. See text.

Double Whip. A tackle with two single blocks and standing part not secured to one of the blocks—mechanical advantage = 2.

Doubling. Sailing around a point of land.

Dowse. To take in, or lower a sail; to put out a light; to cover with water.

Downhaul. A rope led from the head of a headsail and through a block at the foot of the stay for hauling down the sail.

Down the Mast. Said of the wind when there is none.

Draft. The depth of water to a vessel's keel.

Drag. A heavy frame dragged along the bottom as in oyster dredging; a semi-submerged contrivance for keeping a vessel's head to wind and sea; the excess in draft aft over that forward.

Dragging Anchor. To haul the anchor along the bottom when it fails to hold.

Drag Net. A net used by a fishing vessel and dragged along the bottom.

Drainage. The system of pipes

and pumps installed on board ship to expel water.

Draw. A sail when bellied out by the wind is said to draw.

Dredge. A vessel employed in digging out a channel.

Dressing Lines. The lines used in dressing ship.

Dressing Ship. A display of national colors at all mastheads and the flagstaff. (Full dressing ship requires in addition a rainbow of flags from bow to stern over the mastheads.)

Drift. The leeway of a vessel or amount of set of a tide or current; the spare end of a rope.

Drifter. A fishing boat, drifting but secured to her nets.

Drift Lead. A lead of from 30 to 50 pounds dropped over the side when at anchor to give notice if the vessel drags.

Drift Net. A net used by a fishing vessel and floating to windward of the vessel.

Drive. To be forced to leeward under no control of sails or rudder. To force a sailing vessel with a press of sail.

Driver. A term sometimes used for a spanker.

Drop Down. To sail or steam down towards a river's mouth; an order for a ship's boat to cast off from the boom and back down to the gangway.

Dry Bulb Thermometer. An instrument for measuring the temperature of the air.

Dry Dock. A basin for receiving a vessel for repairs, capable of being pumped dry.

Duff. A sailor's food of flour and water, called *plum duff* if raisins are added.

Dug-out. A boat made from a hollowed-out tree trunk.

Dumb Compass. Same as Pelorus.

Dungarees. Blue working overalls.

Dunnage. (1) Loose material placed in holds for the cargo to rest on, or jammed between the cargo to wedge it. (2) A sailor's personal effects.

Dutch Courage. False courage due to liquor.

Earing. A short piece of rope secured to a cringle for hauling out the cringle.

Ease Her. An order to put the helm alee, to luff into the wind or sea.

Ease In. To gradually work in, as to a dock.

Ease Off. To slack up.

Ease Out. To slack out.

Ease the Rudder. An order to decrease the rudder angle.

Ease Up. To gradually work up; to let up.

Easing-out Line. A line used in clearing hawse and in mooring, for easing out a chain which has been unshackled.

Easy. Carefully.

Eating to Windward. Same as beating to windward.

Edge Away. To gradually pay off from the shore or from a course.

Elbow. Two crosses in a hawse.

Embark. To go on board.

End-for-end. Reversing the position of an object.

End Link. The open link next abaft the bending shackle.

End on. Head on.

End Seizing. A round seizing at the two ends of a rope.

Engine Order Telegraph. An apparatus between a steering station and the engine-room for signalling the desired engine maneuvers.

Engine Revolution Telegraph. An electrical apparatus between a steering station and the engine-room for signalling the number of revolutions desired.

Enlarged Link. A link of enlarged width connecting a common link to a short or long-end link or to a swivel.

Ensign. (1) The national flag

(2) A junior officer in the U. S. Navy.

Entrance. The portion of a vessel's bow just above the waterline.

Euphroe. A length of wood with parallel holes, used to spread the legs of the crow's foot of an awning.

Even Keel. Floating level.

Eyebolt. A bolt terminating in an eye used for securing purposes.

Eye Brow. The metal lip over an airport to carry the water to the side of the port.

Eyelet Holes. The holes in a sail for reef-points or robands.

Eye Seizing. A seizing for shortening up an eye, the turns of the seizing stuff being taken over and under each part and the ends crossed over the turns.

Eye Splice. See text.

Eye Splice, Four-Stranded. Same as eye splice, tucking four times.

Eyes. The foremost portion of the weather deck in the bow of a ship.

Fag. The end of a rope frayed or untwisted.

Fair Leader. An eye to furnish a clear lead.

Fairway. An open channel.

Fair Tide. A tide running with the vessel.

Fair Wind. A favoring wind.

Fake. A single turn of rope when a rope is coiled down.

Fake Down. To coil down a rope so that each fake of rope overlaps the next one underneath, and hence the rope is clear for running.

Falling Glass. Lowering atmospheric pressure as registered by the barometer.

Falling Home. Said of a vessel's sides when they incline up and inboard.

Falling Off. Paying off from the wind.

False Keel. A thin keel spiked to the lower side of the main keel of wooden or sheathed ships as a protection to the keel.

Fanning. Said of a sailing vessel when proceeding slowly in light airs.

Fantail. (1) The part of the stern of a vessel extending abaft the sternpost. (2) In light craft such as destroyers and cruisers, the after section of the main deck.

Fathom. Six feet.

Fathometer. An electrical sound apparatus for measuring automatically the depth of the water.

Favor. To lighten the load, especially of a spar or sail.

Feather. Turning the blade of an oar horizontally at the finish of a stroke.

Feel the Helm. Said of a vessel when she is sensitive to the rudder.

Feel the Way. To proceed cautiously with the lead going.

Fender. Canvas, wood or rope used over the side to protect a vessel from chafing when alongside another vessel or a dock.

Fender Spar. A spar floating secured alongside a vessel to keep the vessel off a dock.

Fend Off. To push off when making a landing.

Fetch. To make a windward mark without another tack.

Fibre Rope. Hemp and Manila rope.

Fiddle Block. An elongated shell with two sheaves, the larger one on top; the falls lead the same way.

Fiddley. The iron framework around the ladder of a deck hatch leading below decks.

Field Day. A day for general ship cleaning.

Figure Head. A carved wooden figure carried on old sailing vessels under the bowsprit.

Figure-of-eight. See text.

Fill Away. (1) The sails are said to fill away when they are

bellied out as the nose of the boat falls off from the wind. (2) Said of a boat as she gathers headway on a new tack.

Filling Pieces. Blocks of wood fitted athwartship between the keel and keelson.

Fine. Sharp forward.

Fire Control. Pertaining to the direction and the control of a vessel's battery.

Fire Hose. The hose used for fire purposes.

Fire Main. The large pipe running fore-and-aft underneath the protective deck for distributing water to the fire plugs.

First Lieutenant. The officer charged with the cleanliness of a man-of-war, and who is in charge of the C and R equipment.

Fish. To heave the flukes of an anchor to the billboard. Repairing damage to a spar by bolting wooden pieces called fish pieces or fronts over the break and securing them with strong lashings.

Fish Block. The lower block of a fish tackle and fitted with a fish.

Fish Davit. The davit used in fishing an anchor.

Fisherman's Bend. See text.

Fisherman's Grease. Water used for lubrication.

Fish Hook. A large iron hook used to catch the arm of an old-fashioned anchor and to hoist the fluke onto the billboard.

Fish Tackle. The tackle used in fishing an anchor.

Flagstaff. The staff to which the ensign is hoisted.

Flare. The outward and upward curve in the form of a vessel's bow. The curve of a vessel's bottom from the water-line to the keel.

Flaring. Said of a vessel's sides when they incline up and outboard.

Flare-up. A light signal designed to blaze or flare up.

Flat. As close as possible, as a flat sheet.

Flat Calm. An absolute calm with a flat sea.

Flat Seizing. A seizing for stopping the end of a rope to its own part, a number of round turns being taken and the end led back through the turns and through a bight of the other end.

Flatten In. To haul in the sheets.

Flaw. A sudden gust of wind.

Fleet. To shift from place to place, e.g., to fleet forward on a boat-fall; specifically to draw the blocks of a tackle apart.

Flemish Down. To coil flat down on deck, each fake outside of the other beginning in the middle and all close together.

Float. A decked-over raft sometimes moored alongside the foot of an accommodation ladder when many visitors are expected on board.

Flotsam. Floating wreckage or goods.

Floor. The more or less horizontal portion of the bottom of a boat and on which she rests when aground.

Floor Plates. Removable iron plates forming the deck plating in fire and engine rooms.

Flow. To ease out the sheets, so as to spill the wind.

Fluke. The flat extremity of the arm of the anchor which bites into the ground.

Flush Deck. A continuous upper deck with no breaks such as raised forecastle or poop.

Flushing Main. The large pipe running fore-and-aft underneath the second deck for distributing flushing water.

Flushing System. The salt water system for supplying toilets, washroom, laundry, etc.

Fly. The end of a flag away from the halliards.

Flying Moor. See text.

Flying Start. A racing start on time signal with a preparatory and a starting signal.

Fog Bound. Said of a vessel when forced to lie at anchor due to a fog.

Fog Horn. A sound signal device operated by the mouth or by mechanical appliances.

Fog Signal. A sound signal used in thick weather.

Fogy. An increase of pay due to length of service without increase in rank.

Foot-board. An athwartship piece of wood fitting into notches and used as a brace for an oarsman.

Footling or Floor-board. Fore-and-aft planking fitted on top of the keelson.

Foot Rope. Rope secured under a yard, bowsprit or boom for a foot support when working.

Fore and Aft. In the direction of the keel.

Forecast. A weather prediction.

Forecastle. (1) The upper deck forward of the foremast. (2) A foreward compartment where the crew live.

Forecastle Deck. A partial deck at the bow over the main deck.

Forefoot. The heel of the stem where it connects to the keel.

Forehand. To take the strain by hand on a piece of running gear inboard of the block, so that it may be belayed.

Forelock Pin. A steel pin locking the shackle bolt to the shackle.

Fore Peak. The part of the vessel below decks at the stem.

Fore Reach. A vessel fore reaches when she shoots ahead to windward in tacking.

Foresail. (1) The sail spread by the fore gaff and boom. (2) The lowest sail on the foremast.

Fore Staysail. The head sail next forward of the foremast and setting on the fore stay.

Fore Topmast Staysail. The head sail setting on the fore topmast stay.

Forge Ahead. To make progress ahead, especially when carried ahead by momentum.

Forward Bow Spring. A bow spring leading forward, checking a vessel from coming astern; generally used in mooring or docking.

Forward Brow. The brow thrown over to the forecastle.

Forward Platform. The platform in the eyes of a boat and forward of the foremast.

Forward Quarter Spring. A spring from the quarter leading forward, checking a vessel from coming astern; generally used in mooring or docking.

Forward Waist Spring. A spring from amidships leading forward, checking a vessel from coming astern; sometimes used in mooring or docking.

Foul. Jammed; not clear.

Foul Anchor. Said of an anchor when the cable is twisted about it.

Foul Hawse. Said of the hawse when moored and the chain does not lead clear of the other chain.

Found. Equipped.

Founder. To sink.

Four Bells and a Jingle. Full speed ahead. In a hurry.

Four-fold Block. A block with four sheaves.

Four-fold Purchase. A tackle with two four-fold blocks—mechanical advantage = 8.

Fourth Deck. A complete deck next below the third deck.

Fox. Two yarns hand-twisted or a single yarn twisted against its natural lay; used for light seizings.

Frame. The ribs of a ship, strengthening and supporting the shell plating.

Franklin Life Buoy. A patented brass life buoy which when released and striking the water automatically ignites two lighted arms.

Frap. To pass ropes around a sail or awning to secure it from blowing loose; to pass tight wrappings of rope.

Free. Not close hauled.

Freeboard. The distance from the water line to main deck or gunwale.

Freeing Port. A port about three feet long and 18 inches wide in the bulwarks for the purpose of freeing the deck of water.

French Bowline. See text.

Fresh Breeze. A force of wind 17 to 21 knots.

Fresh Gale. A force of wind 34 to 40 knots.

Freshen the Nip. To shift a rope so as to take the wear in another place.

Full and By. Sailing close hauled, with all sails full and as close to the wind as possible.

Full Due. Completely; to the fullest extent.

Full Spread. Having all sail set.

Furl. To gather up and secure a sail or awning.

Furling Line. A small line secured to the mast and used for furling a fore-and-aft sail.

Gadget. An unseamanlike term used when the correct term is forgotten.

Gaff. The spar to which the head of a fore-and-aft sail is secured.

Gaff Topsail. The topsail set over a gaff with its foot spread by the gaff.

Gaff Vang. A rope leading from the peak of a gaff to a vessel's rail and used to steady the gaff.

Gage. A position towards or away from the wind or sun, with reference to another vessel.

Gain the Wind. To get to windward of another sailing vessel.

Gale. A force of wind 28 to 55 knots.

Galley. The ship's kitchen.

Gallows. The framework sometimes fitted above the main or superstructure deck for boat stowage and for the stowage of spare parts.

Gang-Board. The fore-and-aft plank in a boat running amidships from the forward platform to the after thwart.

Gangway. An opening in the bulwarks or the rail to give entrance to the ship. An order to stand aside and get out of the way.

Gangway Ladder. Same as accommodation ladder.

Gantline (Girtline). A line rove through a single block secured aloft, e.g., hammock gantline.

Garboard Strake. The strake next to the keel.

Gasket. A small piece of canvas or line used for furling a sail.

Gather-way. To attain headway.

Gear. The general name for ropes, blocks, and tackles, etc.

General Quarters. Battle stations.

Genoa. A large jib.

Gentle Breeze. A force of wind 7 to 10 knots.

Ghosting. Said of a sailing ship when making very little progress.

Gig. A ship's boat designated for the use of a commanding officer.

Gilguy (or Gadget). A term used to designate an object for which the correct name is forgotten.

Gimbals. A pair of rings one within the other and with axes at right angles to one another for supporting the compass and maintaining it horizontal.

Gin Block. A metal block with an open metal shell.

Gingerly. Cautiously.

Gipsey (Gypsey). A drum of a windlass for heaving in line.

Girt. Said of a vessel when moored with such a taut mooring that she does not swing to tide or wind.

Give Chase. To pursue.

Give 'way. In rowing, an order to begin pulling.

Glass. A term used by mariners for barometer.

Glory Hole. A term applied to the lazarette.

Go About. To tack.

Go Adrift. To break loose.

Go Free. To sail with the sheets eased and the wind abaft the beam.

Go Large. Same as to go free.

Goose-neck. An iron hook secured to the inner end of a boom having no jaws, and fitting into an iron eye carried on the mast.

Grab Rope. A line secured waist high above a boat-boom or gangplank, used for steadying oneself.

Grafting. A rope or ring covering of woven yarns.

Granny Knot. See text.

Grapnel. A small anchor with several arms used for dragging purposes.

Grappling Iron. Same as grapnel.

Grating. A wooden lattice-work platform covering a hatch or the bottom boards of a boat; similarly designed gratings of metal are frequently found on shipboard.

Graveyard Watch. The middle watch.

Great Guns. A violent wind.

Green Sea. A large body of water taken aboard.

Grip. Said of an anchor when it bites and holds.

Gripe Lashing. A lashing spliced to the legs of the gripes and secured either to the davit head or the strongback.

Gripes. Metal fastenings for securing a boat in its cradle; canvas bands fitted with thimbles in their ends and passed from the davit heads over and under the boat for securing for sea.

Grommet. A ring of rope formed by a single strand laid three times around.

Gross Tonnage. The total cubical interior space of a vessel.

Grounding. Running ashore.

Ground Swell. The swell encountered in shoal water and which is practically constant.

Ground Tackle. A term used to cover all of the anchor gear.

Gudgeons. A support for a rudder consisting of metal braces bolted to the stern post and with eyes to take the pintles of the rudder.

Guess Warp. A line from forward rove through a thimble at the outer end of a boat boom, used for securing a boat to the boom. A toggle is fitted through the line abaft the thimble. In general, a hauling line laid out by a boat; a portion of the line is coiled down in the boat.

Gun Deck. A name applied on old vessels to a deck carrying guns and between the main and berth decks.

Gunport Shutter. The metal shutter closing a gunport.

Gun Tackle Purchase. A tackle with two single blocks—see text.

Gunwale. The upper edge of a vessel or boat's side.

Gust. A sudden momentary increase in the wind.

Guy. A steadying rope.

Gybe (sometimes spelled jibe). When sailing free to put the helm over so as to bring the boom on the opposite side.

Gyro Compass. A compass consisting of a rapidly spinning rotor so swung as to maintain its axis in the geographical meridian and pointing to the true North.

Hail. To address a vessel. To come from, as to hail from some port.

Half Deck. A partial deck above the lowest complete deck and below the main deck.

Half Hitch. See text.

Half-mast. The position of a flag when hoisted half way.

Half-rater. A small sail boat carrying jib and mainsail and with no bowsprit.

Half Seas Over. Well under the influence of liquor.

Halliards. Ropes used for hoisting gaffs and sails.

Hamber Line (Hambroline).

Three - stranded seizing stuff, tightly laid.

Hammock. A sailor's bed, made of canvas and swung at each end to the deck beams.

Hammock Cloth. The canvas weather cover over the hammock nettings.

Hammock Nettings. The boxes for stowage of hammocks.

Hand. A member of the ship's company. To furl a sail.

Hand Hole. A small hole in shell plating for access by hand.

Handle. To take charge of, especially of a vessel when making an evolution.

Hand Lead. A lead of from 7 to 14 pounds used with the hand lead line for ascertaining the depth of water in entering or leaving port.

Hand Over Hand. Rapidly; specifically, to climb a rope by placing the hands alternately above one another.

Hand Rail. A steadying rail of a ladder.

Hand Rope. Same as grab rope.

Handsomely. Carefully, not necessarily slowly.

Handspike. A small wooden bar similar to a capstan or an anchor bar, used for prying.

Hand Steering Gear. Steering gear operated with no other power than hand.

Hand Taut. As tight as can be pulled by hand.

Handy. Useful; a handy vessel is one which handles easily.

Handybilly. A watch tackle; a small portable force pump.

Hanging Stage. A plank hung by each end over the side for men to sit on while working over the side.

Hank. Metal or wooden rings on a stay for securing the luff of a headsail.

Harbor Master. The official in charge of the anchorage, berths and harbor regulations of a port.

Hard-a-lee. To put the tiller all the way down.

Hard-a-weather. To put the tiller all the way up.

Hard Down. An order to put the tiller as far to leeward as possible.

Hard Over. An order to put the tiller or wheel as far over to the side designated as possible.

Hard Up. An order to put the tiller as far to windward as possible.

Hash Mark. Slang expression for a diagonal strip on an enlisted man's sleeve to denote a previous enlistment.

Hatch. An opening in a ship's deck for communication or for handling stores or cargo.

Haul. To pull; a change of wind in the direction of the hands of a clock.

Hauled Up. Changing course closer to the wind.

Hauling Line. A line sent down from aloft and used in hauling up a piece of gear.

Hauling Part. That part of the fall of a tackle upon which power is applied.

Haul to Windward (also called hauling her wind). To bring a vessel to the wind when sailing free.

Hawse. The horizontal distance between the stem of a vessel at anchor and a point in the water directly over her anchor.

Hawse Block. The wooden block used as a plug to close the hawse hole.

Hawse Buckler. An iron plate covering a hawse hole.

Hawser. A large rope used for heavy work, such as towing.

Hawser-laid. Same as cable-laid; also a general term for all left-handed rope.

Head. The ship's water closet. The upper edge of a quadrilateral sail.

Head Room. The height of the decks, below-decks.

Head Sails. Sails forward of the foremast.

Head Sheets. The sheets of head sails.

Head Stay. A forward stay.

Head to Wind. The situation of a vessel in the eye of the wind.

Heads Up. A warning to look out.

Headway. Moving ahead.

Heart. The inside center strand of a rope.

Heave. To throw. The rise and fall of a vessel in a seaway.

Heave Away. An order to haul away or to heave around a capstan.

Heave Down. To list a vessel over in order to inspect, repair or clean a vessel's bottom.

Heave In. To haul in.

Heave Round. To revolve the drum of a capstan, winch or windlass.

Heave Short. To heave in until the vessel is riding nearly over her anchor.

Heave Taut. To haul in until the line has a strain upon it.

Heave the Lead. The operation of taking a sounding with the hand lead.

Heave the Log. The operation of taking a speed measurement by use of the chip log.

Heave To. To bring a vessel's head to the wind or sea and hold her there by the use of sails or engines.

Heaving Line. A small line secured to a hawser and thrown to an approaching vessel or to a dock, for a messenger.

Heel. The lower end; to list over; a vessel turns on her heel when she turns in a short space.

Heel-and-Toe. A continuous watch stood by all members on the watch list relieving in succession.

Helm. The tiller.

Hemp. Rope made of the fibers of the hemp plant; used for small stuff of less than 24 thread (1¾-inch circumference).

Hermaphrodite Brig. A brig without a square mainsail (American); same as brigantine (British).

High. An area of high atmospheric pressure.

High-and-Dry. With no water surrounding.

Hogged. With the two ends of a vessel lower than the middle. The opposite of sagged.

Hogging Line. A chain bent to the dip rope and secured to a collision mat for hauling the mat under the side of the vessel.

Hoist. The length of the luff of a fore-and-aft sail; the edge of a flag next to the halliards; a display of flags at a yard-arm.

Hoist Away. An order to haul up.

Hoisting Pad. A metal piece bolted to the keel of the boat and with an eye to which the hoisting rod is bolted.

Hoisting Rod. A vertical metal rod bolted to the hoisting pad and to whose upper end the hoisting shackle is bolted.

Hoisting Shackle. A shackle bolted to the hoisting rod or pad and to which the lower block of the boat falls is hooked.

Hold. The space below decks utilized for the stowage of ballast, cargo and stores.

Hold Water. An order to check a pulling boat's headway by holding the blades of the oars vertically in the water with the oars at right angles to the keel.

Holiday. An imperfection; spots left unfinished.

Holystone. A large flat stone used to clean and whiten a vessel's decks.

Home. To the limit; an anchor comes home when it fails to hold and is dragged towards the vessel.

Hood. A covering of wood or canvas over a hatch, companionway or skylight.

Hook. The curved metal piece

fitted at the top of an upper block and used for hooking the block.

Hook Rope. A rope fitted with a hook at one end, for use in handling chain cable.

Horns. The jaws of a boom or gaff. The horizontal arms of a cleat.

Horse, or Deck Horse. The iron bar or strap fastened to the deck and upon which the traveller travels.

Horse Block. The elevated platform of the stern of a sailing vessel, formerly the post of the officer-of-the-deck.

Horse Latitudes. The latitudes on the outer margins of the trades where the prevailing winds are light and variable.

House. To stow or secure in a safe place; a topmast is housed by lowering it and securing it to a lowermast; an awning is housed by hauling the stops down and securing them to the rail.

House Flag. The distinguishing flag of a merchant marine company flown on the mainmast of merchant ships.

House Line. Three-stranded, left-handed rope; used for fine seizing.

Housing. The part of a mast below the upper deck or the part of a bowsprit inboard of the stem.

Housing Anchor. A patent anchor with arms swivelling on the shank; the anchor will house itself in the hawse pipe when hove up.

Housing Chain Stopper. A slip stopper fitted with a screw turnbuckle and used for securing an anchor in the hawse pipe.

Hug. To keep close.

Hulk. A worn-out and stripped vessel.

Hull Down. Said of a vessel when due to its distance only the spars are visible.

Hurricane. A force of wind over 65 knots.

Ice-blink. The white veil around the horizon caused by the reflection of light on an ice field.

Ice-bound. Caught in the ice.

Ice-lead. A lane of open water of temporary nature in an ice-field.

Ice-nip. Two ice fields meeting.

Idlers. Members of a ship's company with no night watches.

Inboard. Towards the fore-and-aft line of the ship.

In Bows. An order to the bow oarsman or oarsmen to boat their oars and stand by with boat-hooks for a landing.

In Irons. The situation of a vessel having missed stays and when she refuses to fall off from the wind.

Inland Rules. The rules of the road enacted by Congress and governing the navigation of inland waters of the U. S.

Inner Bottom. The top of the double bottom and consisting of water-tight plating secured to the reverse frames.

Inner Jib. The headsail next forward of the fore staysail on certain sailing types.

Inner Keel. The keelson.

In Sail. An order to take in the sail.

Inshore. Towards the shore.

In Stays. Headed into the wind with all sails shaking.

Intercardinal. The four points midway between the cardinal points — Northeast, Southeast, Southwest and Northwest.

International Rules. The rules of the road established by agreement between maritime nations and governing the navigation of the high seas.

In the Wind. So close to the wind as to have the wind spilled from the sails.

Invoice. A written statement in detail of a vessel's cargo.

Irish Pennant. An untidy loose end of a rope.

Iron-bound. A block fitted with a metal strap.

Jack. The flag similar to the union of the national flag.

Jackass. A conical canvas stopper stuffed with tarred oakum and hove tight into a between-deck hawse pipe as a watertight stopper.

Jack Rope. The lacing securing the foot of a sail to a boom.

Jack Staff. The staff fitted over the stem to carry the jack.

Jacob's Ladder. A ladder of rope with rungs used over the side and aloft.

Jackstay. A wooden or iron stay bolted to the under side of a gaff for securing the head of a fore-and-aft sail; also a commonly used term for many ropes or rods used for securing purposes.

Jam. To wedge tight; to sail close-hauled.

Jaw Rope. A span of rope leading from the jaws of a gaff around the mast, strung with hard wooden beads.

Jaws. The two horns bolted one on each side of the inner end of a boom or gaff to keep it to the mast.

Jetsam. Goods which sink when thrown overboard at sea.

Jettison. To throw goods overboard.

Jetty. A landing wharf or pier; a dike at a river's mouth.

Jew's Harp. The ring bolted to the upper end of the shank of an anchor and to which the bending shackle secures.

Jib. A headsail set on a stay forward of the foremast.

Jib-boom. A spar rigged out beyond the bowsprit and through the bowsprit cap.

Jib-Headed Rig. A rig with all sails triangular.

Jib Topsail. A headsail on a stay forward of the foremast, setting higher up than the jib.

Jig. A purchase on the bight of a halliard.

Jigger. A light, handy tackle for general work about the decks. The after mast of a four-masted vessel. The small mast set at the stern of a yawl-rigged boat. The sails on these masts may be referred to as jiggers.

Jolly Boat. A small boat used in the merchant service and corresponding to a dinghy on a man-of-war.

Jolly Roger. A pirate's flag carrying the skull and cross-bones.

Jumbo. The fore staysail of a fore-and-aft rig sailing vessel.

Jump (of a sea). A short quick sea.

Jumper. A rope used to prevent a spar from jumping up; specifically, the rope from the outer end of the whiskers to the martingale.

Jumperstay. An extra stay from the masthead to the rail and set up by a tackle.

Jump Ship. To leave a ship without authority.

Junk. Old rope. A Chinese or Japanese lateen-rigged sailing vessel of heavy construction.

Jury Anchor. A heavy weight used as an anchor.

Jury Mast. A temporary mast rigged to the stump of a mast carried away in heavy weather.

Jury Rig. A makeshift rig.

Jury Rudder. A makeshift rudder.

Jute Rope. Rope made from the fibre of the jute plant.

Keckling. Chafing stuff around cables, made of old rope.

Kedge. A small anchor used for kedging, by alternately planting ahead and hauling the ship up to it.

Keel. The timber or bar forming the backbone of the vessel and running from the stem to the sternpost at the bottom of the ship.

Keel Block. The line of wooden blocks at the bottom of a dry dock to take a vessel's keel.

Keel Haul. An ancient punishment, consisting of hauling a person under the keel by whips from the yard-arms.

Keelson. The timber bolted on top of the keel and utilized for strengthening the ship's structure.

Keep Away. To alter the course from the wind or so as to avoid a danger.

Keep Her Full. An order to keep the sails filled.

Keep Her Off. An order to keep further from the wind.

Keep Her So. An order to steady on the course.

Keep Her Up. An order to keep closer to the wind.

Keep Your Luff. An order to hold a sailing ship to the wind without allowing the luff of the sails to lift.

Kelp. Seaweed.

Kenter Shackle. A patent shackle used in connecting shots of anchor chain. In size and shape it corresponds to the ordinary links of the chain.

Kentledge. Permanent pig iron ballast stowed next to the keelson.

Ketch. A sailing vessel rigged like a yawl but with the jiggermast forward of the rudder.

Kettle-bottomed. Having a flat floor.

Kick. The distance the stern of a vessel is thrown away from the direction of a turn, by the action of the rudder.

Killock (Killick). A stone anchor; familiarly applied to any anchor.

Kink. A twist in a rope.

King Post. A short mast to support a boom.

King Spoke. The upper spoke of a wheel when the rudder is amidships, usually marked in some fashion.

Ki Yi. A scrubbing brush.

Knee. An angular piece connecting a vessel's frames to the beams.

Knockabout. A sloop with jib setting from the stem.

Knocked Down. The situation of a vessel when listed over by the wind to such an extent that she does not recover.

Knock-off. To stop, especially to stop work.

Knot. One nautical mile per hour.

Labor. A vessel is said to labor when she works heavily in a seaway.

Lacing. Line used to secure canvas by passing through eyelets in the canvas.

Laden in Bulk. Cargo carried loose in a vessel.

Ladder. A metal, wooden or rope stairway.

Land Breeze. A breeze from the direction of the land, as commonly experienced in the tropics at night.

Land Fall. The first sighting of land at the end of a sea voyage.

Land Ho! The hail from the lookout when land is sighted.

Landing Strake. The second line of planking below the gunwale.

Land-locked. Surrounded by land.

Landlubber. The seaman's term for one who does not go to sea.

Landmark. A conspicuous object on shore.

Lanyard. A rope made fast to an article for securing it, e.g., knife lanyard, bucket lanyard, etc., or for setting up rigging.

Large. To sail large is to sail free.

Lash (and carry). The order to lash up the hammocks and stow them in the nettings.

Lashing. A rope securing two pieces together.

Lateen. A rig peculiar to vessels in the Mediterranean Sea. A lateen sail is a triangular fore-and-aft sail secured to a long yard hoisted obliquely to the mast.

Launch. To place in the water.

Lay. (1) A preliminary order, e.g.: lay aloft, lay out, etc. (2) The direction of the twist of strands of a rope.

Lay Aloft. The order to go aloft.

Lay Days. The number of days beyond which demurrage is paid.

Lay on Oars. An order to a pulling boat's crew to stop pulling and to hold their oars with the blades horizontal and the oars at right angles to the keel of the boat.

Lazarette. A low head-room space below decks in the after part of some ships, used for provisions or spare parts.

Lazy Guy. Running rigging to a steady boom in a seaway.

Lazy-jack. A length of rope secured at the masthead and with a bridle at each end secured to the boom, and for the purpose of preventing the sail from falling on deck when it is lowered.

Leach. The after end of a fore-and-aft sail.

Leaden. Said of the skies when of a dull leaden hue.

Leading Block. A single block used to make a fair lead for running gear.

Leading Part. Same as hauling part.

Lead Line. Line of cotton twine, braided, for boat lead line; of flax twine, braided, for ship's lead line and coasting lead line; and of hemp for deep-sea lead line. The line is secured to the lead.

Leadsman. The seaman detailed to the chains for heaving the lead.

League. A measurement of distance; the English and American measure is three nautical miles.

Leave. Special permission to be absent from ship or station for a longer period than the usual liberty.

Lee-board. A board used as a center-board but secured over the side of a flat-bottomed boat.

Lee Helm. The tiller put to leeward; a vessel carries lee helm when it is necessary to put the tiller to leeward to hold the course.

Lee Helmsman. The assistant helmsman formerly used on the lee side of a sailing ship's wheel.

Lee Shore. The land to leeward of the vessel.

Lee Tide. A tide running with the wind.

Leeward. The direction away from the wind.

Leeway. The drift of a vessel to leeward caused by the wind or tide.

Left-handed. Twisted from right to left or against the sun; strands and cables are usually left-handed.

Leg. The length of a board or a tack of a sailing vessel on the wind.

Leg of Mutton. A triangular lower sail.

Lend-a-hand. To assist.

Let Fall. An order to let the oars fall from the position toss into the rowlocks.

Let Her Off. An order to let the vessel go farther from the wind.

Let Her Ride. An order to allow to remain.

Let Her Up. An order to let the vessel go closer to the wind.

Lewis Bolt. A bolt similar to an eyebolt, usually of brass, fitting into a socket on deck and secured with a wedge; used for securing leading blocks.

Liberty. Permission to be absent from the ship or station for a short period.

Lie-to. Said of a vessel when underway with no way upon her.

Life Boat. A ship's boat particularly adapted for use at sea; fitted with a steering oar passed through a steering crutch on the quarter.

Life Buoy. A ring buoy of cork for life saving.

Life-line. A line secured along the deck to lay hold of in heavy weather; a line thrown on board a wreck by a life-saving crew; a knotted line secured to the span of a life-boat davits for the use of the crew when hoisting and lowering.

Life Preserver. A coat of buoy-

ant material to be worn to keep a person afloat.

Life Raft. A life float constructed either with a metallic tube covered with cork and canvas, or made of balsa wood or other suitable material. They are in four sizes of 67, 41, 28 and 20 person capacity. Each carries two 5-foot paddles.

Lift. A clearing of fog. A piece of standing rigging supporting a yard or boom. To lend a hand.

Light. To lift along; to light up is to slack away; to light out is to move out.

Light Airs. A force of wind 1 to 3 knots.

Light Breeze. A force of wind 4 to 6 knots.

Lighted Buoy. A buoy fitted with a light.

Lightening Hole. A hole cut into plating in order to lighten the plate.

Lighter. A boat used in harbors for transporting merchandise.

Limber Hole. A hole cut in the framing near the keelson to allow water to flow fore-and-aft.

Line. The Equator. A general term for light rope.

Line Fisher. A fishing vessel utilizing a buoyed line lightly anchored at the other end.

Link. One of the units which make up a chain.

Lipper. A small sea coming over the rail.

List. The athwartship inclination of a vessel due to excess of weight on one side.

Lizard. A rope fitted with a thimble or thimbles and used as a leader for running rigging; a travelling lizard is fitted to the middle of a life-boat's falls for use in taking up the slack when hoisting.

Lock. A compartment in a canal for bringing a vessel to a higher or lower level.

Locker. A storage compartment. A clothes wardrobe.

Lofty. Towering; high.

Log Book. A book containing the official record of a ship's activities together with remarks concerning the state of the weather.

Log Line. Line of hemp for chip log line; and of cotton twine, braided, for taffrail log line. The line is secured to the log.

Long Board. A long stretch on one tack.

Long-end Link. An elongated link with stud placed near one end connecting the after end of a shackle to an enlarged link.

Longitudinal. A fore-and-aft strength member of a ship's structure.

Long-Legged. A deep draft vessel.

Longshoreman. A laborer loading and discharging cargo.

Long Splice. See text.

Long Tackle. A tackle with two sets of double single-sheave blocks. Power = 4 or 5.

Lookout. The man stationed aloft or in the bows for observing and reporting objects seen.

Look Up. To point closer due to a favorable shift of wind.

Loom. The part of an oar between blade and handle. The reflection of a light below the horizon due to certain atmospheric conditions.

Loose. To unfurl a sail.

Loose-Footed. A sail whose foot is not laced to a boom.

Louvre. A metal cap covering the end of a ventilator pipe below decks and fitted with wire mesh.

Low. An area of low atmospheric pressure.

Lower Away. An order to lower down.

Lubber's Point. The vertical black line marked on the inner surface of the bowl of a compass indicating the compass direction of the ship's head.

Lucky Bag. A locker or compartment for the stowage of loose articles of clothing found about the ship.

Luff. The forward edge of a fore-and-aft sail.

Luff-earing. A short length of rope used to secure the reef cringle on the luff of a sail to the foot of the sail or to the boom in reefing.

Luff Her. An order to bring the vessel into the wind by putting the helm down.

Luff Tackle. See text.

Luff Upon Luff. See text.

Lug. A rig with a quadrilateral sail carried on a yard hoisting on the mast; different types are French lug, balance lug, split lug, standing lug and dipping lug. To carry an excessive amount of sail.

Lugger. A sailing vessel with quadrilateral fore-and-aft sails, the head carried on a hoisting yard, and the luff shorter than the leech.

Lull. A temporary cessation or abatement of the wind.

Lurch. A sudden roll of a vessel.

Lyle Gun. A gun used in the life-saving service to throw a life-line to a ship in distress.

Mackerel Sky. Cirro-cumulus, patchy clouds.

Made. Not whole—in parts.

Magazine. The space provided for the stowage of explosives.

Magazine Flooding System. The salt-water system for flooding magazines.

Magnet. A polarized piece of metal, each end of different polarity.

Magnetic Compass. A compass in which the card carries bundles of magnets and thus points towards the magnetic pole.

Main Deck. The highest deck extending from stem to stern; in old vessels, the highest covered deck.

Main Drain. A large pipe running fore-and-aft and connecting the main circulating pumps with all parts of the ship, for expelling water.

Mainsail. The sail spread by the main gaff and boom.

Make Colors. Hoisting the ensign at 8 a.m.

Make Sail. An order to set the sails.

Make Sunset. Lowering the colors and turning on required lights at sundown.

Make the Course Good. Steering and making good the designated course.

Make the Land. A landfall.

Make Water. To leak.

Manger. In old vessels the space abaft the hawse pipes from which water was excluded by a low coaming.

Manhole. An opening into a tank or compartment designed to admit a man.

Manifest. A document made out by a vessel's master where goods are received, detailing the cargo, and submitted to the customs authorities.

Manifold. A metal chest containing valves for connection to pumps and mains.

Manila. Rope made from the fibers of the abaca plant.

Manrope Knot. See text.

Man Ropes. Ropes hung over a ship's side and used for assistance in ascending or descending.

Man the Boat. An order to embark.

Marconi Rig. A sloop rig with a high leg-of-mutton sail.

Mares' Tails. Cirrus clouds, portending wind.

Marine Glue. A substance resembling gutta-percha and sometimes used in caulking decks as a substitute for pitch.

Maritime. Pertaining to the sea.

Mark. The fathoms of a lead line which are marked. The call used in comparing watches, compass courses or bearings.

Market Boat. The boat sent ashore in the morning watch with stewards for provisions.

Marl. Marling hitches securing parcelling.

Marline. Two - stranded, left-handed rope; used for fine seizings and for sennit.

Marlinespike. A pointed iron instrument used in working with rope and wire.

Marline Spike Hitch. See text.

Marling Hitch. See text.

Maroon. To put a person ashore with no means of returning.

Marry. To place two ropes together as in hoisting a boat; to temporarily sew the ends of two ropes together for rendering through a block.

Mast. A vertical spar supporting the booms, gaffs and sails, or in a steamer, supporting the signal yard. In a man-of-war, mast is the term for the hearing of cases of breach of discipline.

Master Compass. The gyro compass controlling the repeaters.

Mast-Head. The top of a mast.

Masthead Light. The white running light carried by steam vessels underway on the foremast or in the forepart of the vessel.

Mast-Hole. A hole in a deck on thwart of a boat through which a mast passes.

Mast Hoop. A wooden hoop around a mast to which the luff of a fore-and-aft sail is secured.

Mast Step. The frame on the keelson into which the heel of a mast is fitted.

Single Matthew Walker Knot. See text.

Double Matthew Walker Knot. See text.

Maul. A heavy hammer.

Meal Pennant. The red pennant flown at the yardarm of men-of-war at anchor during meal hours.

Meet Her. An order to shift the rudder to check, but not entirely stop, the swing.

Mend. To rebend sails to a boom or spar. To refurl an improperly furled sail.

Mercurial Barometer. A barometer containing mercury and registering by the level of a column of mercury under the influence of the atmospheric pressure.

Meshes. The openings in the cords of a net.

Messenger. A light line used for hauling over a heavier rope or cable; in old sailing ships, a line led to the capstan to assist in heaving in the chain.

Mess Gear. Equipment for serving meals.

Metallic Boats. See text.

Metal Mike. The automatic steering device fitted on board ships.

Meteorological. Pertaining to the weather.

Mid-Channel Buoy. A buoy placed in the middle of a channel to be passed on either side. (In United States black and white vertical stripes.)

Middle a Rope. To double a rope so that the two parts are equal in length.

Midshipman. Differs slightly in various services; in general a naval cadet.

Midshipmen's Hitch. An eye in a rope which will slip.

Mildew. Black and green spots on sails, caused by dampness.

Mind Your Rudder. A warning to the steersman, to watch his course carefully.

Mind Your (Right) Rudder. A warning that (right) rudder must be used to steady the course.

Mirage. An optical phenomenon due to excessive refraction and displacing, vertically, objects on the horizon.

Miss Stays. The situation of a vessel which has failed to come about.

Mitchboard. A crutch.

Mizzen. The third mast from forward of a vessel with more than two masts.

Moderate Breeze. A force of wind 11 to 16 knots.

Moderate Gale. Force of wind of 28-33 knots.

Moderate Speed. The speed low enough under existing conditions to enable a vessel to avoid collision when a danger is sighted.

Mole. A breakwater used as a loading pier.

Monkey Block. A small single swivel block.

Monkey Fist. A knot worked into the end of a heaving line.

Monkey Gaff. The light gaff fitted on some vessels on the after masthead for the display of the colors when underway.

Monsoon. A wind found in the China Sea and Indian Ocean caused by a barometric gradient, and blowing for months in the same direction.

Mooring. Securing to a dock or to a buoy, or anchoring with two anchors.

Mooring Buoy. A buoy fitted with a ring and used for mooring a ship.

Mooring Chain. A chain sometimes used in place of or in addition to other lines, in mooring a vessel to a dock.

Mooring Staple. A large iron staple bolted to a vessel's side for the lead of mooring chains.

Mooring Swivel. A large heavy swivel with two links and shackles attached to each of its parts, for use in mooring ship.

Morning Order Book. The book in which the Executive Officer writes his instructions for the next morning's ship's work.

Morse Code. A code consisting of dots and dashes, used in radio and visual messages.

Morticed Block. A block made out of a single piece of wood with the space for the sheave chiselled out.

Mother Carey's Chickens. The stormy petrel.

Motor Boat. A fast power boat issued to vessels of the U. S. Navy for officers' use. They are issued in the following sizes: 20 feet, 26 feet, 35 feet, 40 feet, and 50 feet.

Motor Dory. A power dory used for officers of destroyers and small ships.

Motor Launch. A heavy power work boat, issued to ships of the U. S. Navy and used for ship's heavy work, from 24 feet to 50 feet overall. Fitted with sails, 24 footers with standing lug rig and 30 to 40 footers with sloop rigs; 50 footers not fitted with sails.

Motor Whaleboat. A power whale-boat issued to ships of the U. S. Navy for life-boat duty, 26 feet overall. Fitted with sails of double standing lug rig, without jib.

Mousing. Small stuff seized across a hook to prevent it from unhooking.

Mud Scow. A large flat-bottomed boat used to carry the mud from a dredge.

Muffled Oars. Oars silenced in pulling by soft chafing gear secured around the looms.

Mug Up. To have a cup of coffee.

Mushroom Anchor. An anchor without a stock and shaped like a mushroom.

Mushroom Ventilator. A ventilator cowl shaped like a mushroom.

Muster. To assemble the crew and verify the absentees.

Mutton, Leg of. A sailing rig in which the sail is three-sided and without boom, gaff or sprit.

Nautical. Pertaining to ships.

Naval Stores. Oil, turpentine, pitch, etc.

Navigable. Sufficient depth of water to permit the passage of vessels.

Navigable Semi-Circle. That semi-circle of a circular storm in which the velocity of the wind's rotation is opposed to the velocity of the storm's translation.

Navigator. The officer charged

with the safe navigation of the vessel.

Navy Standard Shackle. See kenter shackle.

Neaped. Said of a vessel when aground at the height of a spring tide.

Neap Tide. A tide of minimum range, coming at the first and third quarter of the moon.

Neptune. The mythical god of the sea.

Nest. Boat stowage in which one boat in placed inside another. Also refers to two or more small vessels moored together.

Netting. A rope net work.

Net Tonnage. The cubical space available for carrying cargo.

Nigger Heads. Drums for heaving in lines. (See Gypsey.)

Nimbus. A thick layer of dark clouds without shape, from which rain or snow generally falls.

Nip. A short turn in a rope.

Nock. The forward upper corner of a boom sail.

No Higher. An order not to let the vessel come closer to the wind.

Norman. A pin through the head of a bollard to prevent hawsers from slipping off.

Nose. A vessel's cut-water.

Nothing Off. An order not to allow the vessel to pay off further from the wind.

Nothing to the (Westward). An order not to allow the vessel to pay off further to the (westward).

Nothing to the Right (Left). An order to the steersman not to let the ship's head go to the right (left) of the course ordered.

Not Under Command. Said of a vessel when disabled from any cause.

Not Under Control. Same as not under command.

Number. A flag hoist of alphabet flags to denote a vessel's identity. To make one's number is to present oneself.

Nun Buoy. A buoy with a conical top found on the starboard hand on entering a channel and painted red.

Oakum. A material used for caulking the seams of vessels and made from the loose fibers of old hemp rope.

Oar. A wooden implement used to row a boat.

Oarlock. Same as rowlock.

Oars. An order to stop pulling temporarily and to lay on oars.

Ocean Greyhound. A fast merchant steamship.

Off-and-On. Standing towards the land and off again alternately.

Officer-of-the-Deck. The officer in charge of the ship and on deck as the Captain's representative.

Officer-of-the-Watch. The officer in charge of the Engine Room watch.

Offing. To seaward but in sight of land.

Offshore Wind. A wind blowing off the land.

Off the Wind. Sailing free.

Oil Bag. A bag filled with oil and triced over the side for making a slick in rough seas.

Oiling. Taking on board fuel oil.

Oil King. The petty officer of the Engineer's Force in charge of fuel oil storage.

Oilskins. Waterproof clothing.

Old-Fashioned Anchor. An anchor with a stock at right angles to the arms, the stock being capable of being laid down on the shank; it is fished and catted and stows on the billboard.

Old Man. The captain of the ship.

On Soundings. Said of a vessel when the depth of water can be measured by the lead—within the 100-fathom curve.

On the Beam. Same as abeam.

On the Bow. The bearing of an object from 0 to 45 degrees from ahead.

On the Quarter. The bearing of

an object from 135 to 180 degrees from ahead.

On the Wind. Sailing close hauled.

Open. Unprotected. Said of a landmark when clear of an intervening mark.

Open Boat. A boat which is not decked over.

Open Hawse. Same as clear hawse.

Ordinary (in). A status of a man-of-war in which the vessel is maintained at a Navy Yard with such complement as to enable the preservation of the vessel from deterioration.

Orlop Deck. A name applied to a lower partial deck below the berth deck and on or above the protective deck on old vessels.

Otter Gear. Paravane gear.

Outboard. Towards the sides of the vessel.

Outboard Motor. A portable motor and propeller slung over the stern of a small boat.

Outer Keel. The vertical keel.

Out-foot. To sail faster than another vessel.

Outhaul. A rope used for hauling out.

Outlying. Objects at a distance from the shore.

Out Oars. An order to a pulling boat fitted with trailing oars to ship the oars in the rowlocks.

Out of Trim. Not properly trimmed or ballasted.

Out-point. To sail closer to the wind than another vessel.

Outreach. The horizontal distance from the end of a cargo boom to its base.

Outsail. To sail past another vessel.

Out-rigger. A spar of wood or iron rigged out to give spread to standing or running rigging.

Over All. The extreme deck fore-and-aft measurement of a vessel.

Overfalls. Breaking seas caused by currents over a shoal area.

Overhand Knot. See text.

Overhang. The projection of the stern beyond the sternpost, and of the bow beyond the stem.

Overhatted. Oversparred.

Overhaul. To separate the blocks of a tackle to lengthen the fall.

Overlap. The situation where an overtaking vessel has forged ahead so as no longer to have the choice on which side to pass.

Over-rigged. When a vessel has heavier gear than is necessary.

Over-sparred. When a vessel has heavier spars than is necessary.

Overtaken. Said of a vessel when she is being overhauled or overtaken by another vessel.

Overtaking. Said of a vessel when she is overhauling or overtaking another vessel.

Packet. A mail boat on a regular run.

Pad Eye. A metal eye permanently secured to a deck or bulkhead.

Painter. A short piece of rope secured in the bow of a small boat, used for making her fast.

Palm and Needle. A seaman's sewing outfit for heavy work.

Paravanes. Fish-shaped metal bodies towed underway from the stems of men-of-war as a protection against mines.

Parbuckle. To handle a spar or cask over the side by the bight of two ropes, the end of each rope secured and the other end tended.

Parcelling. See text.

Parliament Heel. Listed over so as to inspect, clean or repair the vessel's bottom.

Parrel Lashing. The lashing used to keep the gaff of a fore-and-aft sail in to the mast.

Part. To break.

Passage Winds. Same as westerlies.

Pass a Line. To reeve and secure a line.

Pass Down the Line. A signal

repeated from each ship to the next astern in column.

Passenger List. The list containing the names of all passengers embarked.

Pass a Stopper. To reeve and secure a stopper.

Pass the Word. To repeat an order or information to the crew.

Patent Anchor. A stockless anchor, housing in the hawse pipe.

Patent Block. A block having friction rollers for the pin bearing.

Patent Eye. A metal eye secured to the end of a wire rope in place of a spliced eye.

Patent Log. See taffrail log.

Pawls. Short iron bars at the base of a capstan head to prevent the barrel from turning backwards.

Pay. To fill the seams of a vessel with pitch.

Pay Off. To turn the bow away from the wind; to pay the crew.

Pay Out. To slack out on a line made fast on board.

Pea. Same as bill.

Pea Coat. A bluejacket's reefer.

Peak. The upper after corner of a gaff sail.

Peak Halliards. The lines hoisting the peak of a quadrilateral sail.

Peak Tank. Tanks in the bows or stern of a ship, usually for water ballast.

Pelican Hook. A hinged hook held together by a ring. When the ring is knocked off the hook swings open.

Pelorus. A navigational instrument used for taking bearings and consisting of a circular flat metallic ring graduated in degrees and mounted in gimbals on a vertical stand, usually outboard.

Pendant. A length of rope with a block or thimble at the end.

Pendant Tackle. A tackle hooked on to a pendant, used principally in setting up rigging.

Pennant. A three-sided flag.

Perch. A staff or vertical rod on top of a buoy supporting a shape and marking a shoal.

Pier-head Leap. A jump to a dock made by a deserter as soon as a vessel approaches the dock.

Pile. A pointed spar driven into the bottom and projecting above the water; when driven at the corners of a dock they are termed fender piles.

Pilot Boat. A power or sailing boat used by pilots.

Pilot Rules. The rules supplementing the Inland Rules and established and published by the Board of Supervising Inspectors of steam vessels.

Pilot's Luff. To make a weather mark by pinching her.

Pin. The metal axle of a block upon which the sheave revolves.

Pinch Her. To sail so close to the wind as to allow the sails to shiver.

Pinnacle. A sharp pointed rock.

Pintle. A bolt of metal secured to the rudder and fitting into the gudgeon, for a swinging support for the rudder.

Pipe Down. An order to keep quiet; an order dismissing the crew from an evolution.

Pipe the Side. The ceremony at the gangway when the boatswain's pipe is blown when an official comes aboard or leaves a man-of-war.

Pipe to. The boatswain's pipe call to an evolution.

Pitch. A substance obtained from the pine tree and used in paying the seams of a vessel.

Pitch (Propeller). The axial distance a propeller would travel without slip in one revolution.

Pitch Pole. Turned end-over-end in the surf.

Pitometer Log. An electrical mechanical appliance for measuring the speed of the ship through the water, by means of the water pressure in a housing vertical tube in the bottom of the ship.

Pitting. Areas of corrosion.

Pivoting Point. The point in a ship about which she turns.

Plain Sail. The regular working sails of a vessel.

Planking. Broad planks used to cover a wooden vessel's sides, or covering the deck beams.

Plat. To braid; used with small stuff.

Platform Deck. A partial deck below the lowest complete deck; called first, second, etc., from the top, where more than one is found.

Play. Freedom of movement.

Plimsoll Mark. A figure marked on the side of merchant vessels to indicate allowed loading depths.

Plug. A wooden wedge fitting into a plug-hole in the bottom of a boat; the hole is for the purpose of draining water from the boat.

Plume. A long cloud in the form of a plume.

Pneumercator. A gauge for reading the amount of liquid in a tank.

Pod. A group of whales.

Point. To taper the end of a rope. One of the 32 divisions of the compass card. To head close to the wind.

Pole Mast. A complete mast constructed from a single spar.

Pontoon. A type of boat in which buoyancy is secured by a water-tight subdivision of the hull, and not by the addition of air tanks.

Poop Deck. A partial deck at the stern over the main deck.

Pooped. Said of a vessel when a sea breaks over the stern.

Porcupine. The fraying of wire rope.

Port. An opening in a ship's side —such as air-port, gun-port, or cargo-port.

Port Side. The left side of a vessel looking forward.

Portable. Capable of being carried; an electric light plugged into a light fixture and with a long lead of wire.

Port Captain. The official in charge of a line of steamships at a certain port.

Port Lens. The heavy glass lens fitted in air-ports.

Port Sill. The raised sill at the entrance to a drydock on which the caisson rests when in a closed position.

Port Tack. The tack on which the wind comes over the vessel's port side.

Portuguese Man-of-War. A jellyfish with a sail-like protuberance above water.

Pratique. A limited quarantine; a permit by the port doctor for an incoming vessel, being clear of contagious disease, to have the liberty of the port.

Prayer Book. A small holystone.

Precipitation. Rain or snow.

Press of Sail. All the sail that a vessel can carry.

Preventer. A rope used for additional support or for additional securing, e.g., preventer backstay, preventer hawser, etc.

Preventer Hawser. A hawser used in clearing hawse and secured to the chain as a preventer near the slip-hook of the clear hawse pendant.

Pricker. A small marlinespike.

Pride of the Morning. A morning mist often seen before a fine, bright day.

Privileged Vessel. One which has the right of way.

Prolonged Blast. A blast of from 4 to 6 seconds' duration.

Protective Deck. The deck fitted with the heaviest protective plating.

Prow. The part of the bow above the water.

Pulling an Oar. Rowing.

Pulpit. The platform for the harpoon man at the end of the bowsprit of a sword-fishing vessel.

Punt. A rectangular flat-bottomed boat issued to vessels of the U. S. Navy, for painting the ship's

side and general use around the ship's water-line, fitted with oarlocks on each side but usually propelled by sculling.

Purchase. A tackle.

Put to Sea. To leave port.

Quadrant. The metal fitting on the rudder head of some vessels and to which the steering ropes are attached.

Quarantine. Restricted or prohibited intercourse due to contagious disease.

Quarantine Buoy. A buoy painted yellow and marking a quarantine anchorage.

Quarter. That portion of a vessel's sides near the stern.

Quarter Breast. A breast line from the quarter keeping the stern in to the dock; used in mooring or docking.

Quarter Breast Mooring. A chain offshore mooring leading as a breast from the quarter to an anchor; used for permanent moorings.

Quarter Deck. A name applied to the part of the upper deck reserved for the use of officers.

Quarter Mooring. A chain offshore mooring leading aft from the quarter to an anchor; used for permanent moorings.

Quartering Sea. A sea on the quarter.

Quarters. Living compartments. Assembly of the crew of a man-of-war.

Quarters Bill. A vessel's station bill showing duties of the crew.

Quay. A cargo discharging wharf.

Race. A confusion of the water due to conflicting tides; the momentary speeding up of a propeller due to the blades being clear of the water.

Racing Cutter. A specially built pulling boat issued to ships of the United States Navy for inter-ship racing.

Rack. To seize two ropes together with cross turns of spun yarn.

Radio Compass. An apparatus for obtaining the direction of radio sending stations and thus plotting a vessel's position.

Radio Direction Finder. An apparatus for taking bearings of any radio sending set.

Raise. To bring an object on the horizon into clearer view.

Rake. The angle of a vessel's masts from the vertical. To fire lengthwise of the target vessel's decks.

Rakish. Having a rake to the masts; a smart speedy appearance.

Range Alongside. To come close abeam of another vessel.

Range Light. The aftermost light of the central range of two white lights carried by steamers other than those exempted by law.

Range of Cable. A length of cable overhauled on deck out of the locker, so as to pay out when the anchor is dropped.

Rap Full. With all sails filled and not quite close-hauled.

Ratline. A short length of ratline stuff running horizontally across shrouds, for a step.

Ratline Stuff. Small stuff, three-stranded, right-handed, tarred; used for rattling rigging.

Rattle Down. To clove-hitch ratlines across the rigging.

Reach. Sailing with a beam wind; head reaching is forging ahead when lying to; fore reaching is forging to windward when tacking. As sometimes used, sailing with a beam wind.

Ready About. An order to prepare for coming about.

Recognition Signal. A flag display or a sound or light signal used to disclose a vessel's identity.

Recover. The point at the end of the stroke where the oar is pulled out of the water; to swing the oar back from the end of one stroke to the beginning of the next.

Reef. To reduce the area of a sail by making fast reef points and earings.

Reef-band. A band of canvas sewed across a sail in the wake of the reef-points for additional strengthening.

Reef-cringle. A thimble or iron ring spliced in the bolt-rope on the leach and the luff of fore-and-aft sails in line with the reef-points.

Reef-earing. A short length of rope spliced into a reef cringle and used to secure the cringle to the boom.

Reef or Square Knot. See text.

Reef-points. Short lengths of rope sewed on each side of the reef-band and secured around the foot of the sail in reefing.

Reeve. To pass the end of a rope through any lead such as a sheave or fair-lead.

Reeving Line Bend. See text.

Registered Tonnage. See Displacement, Gross Tonnage and Net Tonnage.

Registry. The ship's certificate determining the ownership and nationality of the vessel.

Relieving Tackle. A tackle of double and single blocks rove with an endless fall and used to relieve the regular tiller tackles.

Relieving (Watch, etc.). To take over the duty, as when one watch on deck relieves another.

Render. Said of a rope when it runs easily through a sheave or fair-lead.

Rib. A frame of a vessel.

Ride. To lie at anchor; to ride out—to safely weather a storm whether at anchor or underway.

Ridge Rope. The rope rove through stanchion heads to which the awning stops and lacings are hauled out. The backbone of an awning.

Riding Chocks. The chock on deck through which the anchor chain or towing gear passes.

Riding Down the Rigging. Sliding down the rigging in a boatswain's chair.

Riding Light. Same as anchor light.

Riffle. A small ruffling of the surface water.

Rig. A general description of a vessel's upper works. To set up spars, standing and running rigging of a sailing ship. To fit out.

Rigging. Ropes securing masts and sails.

Right. To return to a normal position, as a vessel righting after heeling over.

Right-handed. Twisted from left to right or clockwise; yarn and rope is usually right-handed.

Right of Approach. Legal authority to come within hail.

Right of Search. Legal authority to search a vessel, especially the right of a man-of-war of a belligerent to board and search a suspected merchant vessel.

Ring. Same as jew's harp.

Ringbolt. A bolt fitted with a ring through its eye, used for leading running rigging.

Ring Rope. The rope used to bend the chain to the anchor ring.

Ring Stopper. The rope or chain securing the upper end of the shank of an anchor on the billboard to a toe of the tumbler arm.

Rips. Disturbances of surface water by conflicting current either by winds or tides.

Rise and Shine. A call to turn out of bunks or hammocks.

Riser. A vertical branch pipe.

Rising. The fore and aft stringers secured to the frames inside a boat upon which the thwarts rest.

Rising Glass. Rising atmospheric pressure as registered by the barometer.

Roach. The curve of the edge of a sail.

Roaring Forties. That geographical belt approximately located in 40 degrees south latitude in which

are encountered the prevailing or stormy westerlies.

Roband (Rope-Band). A small piece of manila or spun yarn used to secure the luff of a sail to the mast hoops or stay hanks.

Rocket. A pyrotechnic display fired in the air as a signal.

Rocks and Shoals. The Articles for the Government of the Navy.

Rode. The anchor line of a small boat.

Rogue's Yarn. Colored yarn used to identify rope.

Rolling Chocks. Supports for engines and boilers. An improper term sometimes used for bilge keels.

Rolling Hitch. See text.

Rope Yarn. Twisted fibres used for rough seizings, and which may be twisted into strands.

Rose Lashing. A lashing in which the parts are crossed alternately over and under, with the end passed around the crossing.

Rotator. A spindle placed at the end of a log line and rotating similarly to a propeller by the action of the water on its radial blades.

Rough Log. The ship's log as written up in pencil by the quartermaster and the officer-of-the-deck.

Round Down. To overhaul a tackle so that the lower block will come down.

Round In. To haul in.

Round Line. Three-stranded, right-handed rope, used for fine seizings.

Round Seizing. A seizing of two ropes together.

Round To. To bring a vessel head to wind.

Round Turn and Two Half Hitches. See text.

Rouse In. To haul in, especially by man-power.

Rowlock. A metal fitting fitted into a socket on the rail of a boat as a rest for an oar; also the square cut into the rail for the same purpose.

Rowser Chock. A closed chock.

Rudder. A flat wooden shape fitted on the stern post by pintles.

Rudder Amidships. Is that position of rudder in which it parallels the keel line of the ship.

Rudder Angle Indicator. An electrical or mechanical appliance to indicate at a steering station the angle of the rudder with relation to the keel line of the ship.

Rudder Braces. Braces fitted to the rudder of a boat.

Rudder Cross-head. An athwartship metal piece bolted and keyed to the top of the rudder post and to which the links of the travelling nut of the steering gear are secured.

Rudder Frame. The frame or main part of a rudder usually covered with plating, and with the space between filled with white pine.

Rudder Hanger. A hollow metal fitting secured to the stern post of a boat and in which the rudder is hung.

Rudder Head. The top of the rudder post.

Rudder Indicator. A mechanical or electrical tell-tale showing the rudder angle.

Rudder Post. The vertical post in single screw vessels upon which the rudder is supported.

Rudder Stock. That part of a rudder by which it is pivoted to the stern post or rudder post.

Ruffles. Roll of the drum used in rendering honors.

Rules of the Road. Regulations enacted to prevent collisions between ships.

Run. The narrowing after part of the under water part of a vessel.

Run Away. To seize a line and haul on the run. To desert.

Run Down. To collide with a vessel head on; to sail north or south to a given parallel of latitude; to stand along a coast.

Runner. See text.

Runner and Tackle. See text.

Running (free). Sailing with the wind astern or on the quarter.

Running Backstays. Used in a yacht to stay the mast, the weather one being set up and the lee one loosed.

Running Bowline. See text.

Running Large. Sailing with wind abaft the beam.

Running Lights. The lights required by law carried by a vessel when underway.

Running Line. A line coiled in a boat and run from the ship to a dock or another ship.

Run Out. To send out, as to run out a towing hawser.

Running Rigging. That part of a ship's rigging which is movable and rove through blocks, such as halyards, sheets, etc.

Sag. The waist of a ship having settled down below the level of the bow and stern; to make leeway.

Sail Cover. A canvas cover used to protect sails from the weather when furled.

Sail Ho! The hail from a lookout to notify that a vessel has been sighted.

Sailing Free. Sailing other than close hauled or into the wind.

Sailing Thwart. A fore-and-aft amidships plank on a small pulling boat for supporting the masts.

Sailing Trim. The trim of a vessel's sails; also said of a vessel when the sails are so trimmed as to make the best possible speed.

Sailing Whaleboat. A whaleboat issued to certain ships of the U. S. Navy, fitted with a centerboard and with jib headed, ketch rig.

Sail Maker's Splice. See text.

Salvage. To save a vessel or cargo from dangers. Recompense for having saved a ship or cargo from danger.

Samson Post. A king post. A short mast supporting auxiliary cargo booms.

Sanitary Systems. Same as Flushing Systems.

Save-All. A sail set under the usual sails to catch such wind as may pass thereunder.

Scale. To climb up; a formation of rust over iron or steel plating.

Scandalize. To drop the peak of a fore-and-aft sail.

Scend. To lift or heave up in a seaway; said of a vessel.

School. A large body of fish.

Schooner. A sailing vessel with two or more masts with fore-and-aft sails and with head sails carried on a bowsprit and jib-boom.

Scoff. To eat.

Scope. The length of chain out.

Score. The groove cut in the sides of a block to take the rope or wire strap; blocks are now usually strapped with iron.

Scotchman. Chafing gear on backstays; a ring on a piece of metal seized to a stay or shroud.

Scow. A large open flat-bottomed boat for transporting merchandise or sand, gravel, or mud.

Scraper. A hand tool for scraping purposes.

Screened Light. A light placed in a box the sides of which will permit the light to be visible only in a certain arc.

Screw. The propeller.

Screw Stopper. A chain stopper fitted with a turn-buckle.

Scud. Low-lying mist clouds.

Scudding. Driving before a gale.

Scull. To propel a boat by working an oar from side to side over the stern.

Scullery. The compartment for washing and stowing dishes.

Scupper. Openings in the side of a ship to carry off water from the waterways or from drains.

Scupper-Lip. The metal projection at the bottom of a scupper for the purpose of keeping the water from the scupper clear of the ship's side.

Scuttle. A small trunk in a vessel's deck; to sink a vessel by boring holes in her bottom, or by opening sea valves.

Scuttle-butt. The container of fresh water for drinking purposes and used by the crew; formerly it consisted of a cask.

Scuttle-butt Story. An unauthenticated rumor.

Sea Anchor. A drag (drogue) thrown over to keep a vessel to the wind and sea.

Sea-boat. A vessel's ability to weather storms; a good sea-boat is a seaworthy vessel.

Sea Breeze. A cooling breeze, blowing generally in the day time from the sea.

Sea Buoy (Farewell Buoy). A large buoy marking the seaward approach to a channel.

Sea Chest. A sailor's trunk. The intake between the ship's side and a sea valve.

Sea Cock. A cock in a pipe connected to the sea; a vessel may be flooded by opening the sea cocks.

Sea Dog. An old sailor.

Sea-going. Capable of putting to sea.

Sea Kindly. Said of a ship when trimmed properly and riding well.

Sea Ladder. A rope ladder usually with wooden steps for use over the side.

Sea Lawyer. A seaman who is prone to argue, especially against recognized authority.

Sea Painter. A line leading from forward and secured to a forward inboard thwart in such a way as to permit quick releasing; it tends to throw the bow of the boat out when the boat is water-borne.

Searchlight. A powerful light with a reflector; when fitted with a shutter it may be used for signalling.

Sea Room. Far enough away from land for unrestricted maneuvers.

Seasoned. Protected against the weather by chemical treatment.

Sea Suction. A connection in the ship's side to the sea.

Seaway. A place where a moderate or rough sea is running.

Seaworthy. Capable of putting to sea and able to meet usual sea conditions.

Secondary Drain. A drain smaller than the main drain and capable of removing small quantities of water by connection to pumps.

Second Deck. A complete deck next below the main deck.

Secret Block. A block designed to prevent fouling by building the shell completely over the sheave with access only large enough on each side for the rope.

Secure. To make fast; safe; the completion of a drill or exercise on board ship.

Secure for Sea. Extra lashings on all movable articles.

Seize. To bind with small rope.

Seizing Stuff. Three-stranded, right-handed, high-grade small stuff, laid up by machinery.

Selvagee. Rope yarn or spun yarn marled together and used as a neat strap.

Semaphore. A code indicated by the position of the arms.

Sennit. Braided rope yarns or spun yarn; known as flat, French, round or square, according to figure braided.

Serving. Additional protection over parceling and consisting of continuous round turns of serving stuff.

Serving Board. A small piece of flat board with a handle used for serving small rope.

Serving Mallet. A wooden mallet with a groove cut lengthwise in its head and used for serving large rope.

Set. The direction of the leeway of a vessel or of a tide or current.

Set Sail. An order to put to sea.

Set Taut. An order to take in

the slack and to take a strain on running gear preparatory to heaving it in.

Set the Course. To give the steersman the desired course to be steered.

Set the Watch. Strictly speaking, to divide a ship's company into watches; the order at 8 p.m. on a man-of-war to station the first watch.

Settee. A lateen-rigged vessel with a long sharp bow.

Settle. To lower; to sink deeper.

Set Up Rigging. To take in the slack and secure the standing rigging.

Shackle. A U-shaped piece of iron or steel with eyes in the ends, closed by a shackle pin.

Shackle Bolt. The bolt or pin of a shackle.

Shaft Alley. Those spaces within a ship through which the shafts pass.

Shaft Direction Indicator. A mechanical apparatus for recording at a steering station the direction of rotation of the propeller shafts.

Shake. A vessel's sails shake when the wind is spilled.

Shakedown Cruise. A cruise of a newly commissioned ship for the purpose of training the crew and testing out all machinery.

Shake Out. To let out a reef and hoist the sail.

Shakings. Waste canvas, rope and small stuff.

Shank. The main piece of the anchor having the arms at the bottom and the jew's harp at the top.

Shank Painter. The rope or chain securing the fluke of an anchor on the bill-board to a toe of the tumbler arm.

Shape. A ball or cone used in distance signals.

Shape a Course. To ascertain the proper course to be steered to make the desired point or port.

Shark's Mouth. The opening in an awning around a mast.

Sharpie. A square built, flat-bottomed, fore-and-aft rigged sail boat with a center-board.

Sheathed. An iron or steel vessel with the shell plating sheathed with wood to a height above the waterline, and with the bottom coppered.

Sheave. The wheel of a block over which the fall of the block reeves.

Sheepshank. See text.

Sheer. The longitudinal upward curve of a deck. A sudden change of course.

Sheer Off. To bear away.

Sheer Pole. An iron rod across the foot of the shrouds, serving to keep the shrouds spread and as a foot rope or ratline.

Sheer Strake. The uppermost strake of a vessel's side.

Sheers. Two spars raised and lashed together at the top to form a support for a tackle for lifting heavy weights.

Sheet. The rope used to spread the clew of head sails and to control the boom of boom sails.

Sheet Anchor. An anchor carried abaft a bower anchor.

Sheet or Becket Bend. See text.

Sheet Bend Double. See text.

Shell. The casing of a block within which the sheave revolves.

Shell Plating. The water-tight plating riveted to the frames.

Shell Room. The space provided for the stowage of projectiles.

Shift the Rudder. An order to shift the rudder over to the other side.

Shingle. Loose gravel on a beach.

Ship. A three-masted square-rigged sailing vessel.

Ship. To enlist; to send on board cargo; to put in place; to take on board.

Ship Control. Pertaining to the direction for a ship's maneuvering.

Ship Keeper. A watchman safe-

guarding a ship in port with no crew on board.

Shipping Articles. The agreement of the ship's officers and the crew with the owners or agents; or, in the Navy, between the Government and the recruit.

Shipshape. Neat, seamanlike.

Ship's Papers. Documents required on board ship by the various authorities.

Shiver. Same as shake.

Shod. An anchor fitted with a shoe; said of an anchor when the fluke does not bite due to its being caked with clay or mud.

Shoe. A fake keel. A wooden guard over the fluke of an anchor. A plank for the heel of a sheer leg. The projection of the keel for a rudder support.

Shoot. To forge to windward in making a mooring.

Shore Boats. Boats operated by civilian personnel, especially those engaged in ship's business.

Shore Up. To prop up.

Short Board. A short stretch on one tack.

Short-end Link. An open link connecting the forward end of a shackle to an enlarged link.

Shorten Sail. To take in or reef some of the sails.

Short Handed. Without sufficient crew.

Short Splice. See text.

Short Stay. When the scope of chain is slightly greater than the depth of water.

Shot. A short length of chain, usually of 15 fathoms.

Shove in Your Oar. To break into a conversation.

Shove Off. To leave; an order to the bowman to shove the bow clear preparatory to leaving a dock or a vessel's side.

Show-a-leg. An order to make haste.

Shroud-laid. Four-stranded, right-handed rope.

Shrouds. Side stays of hemp or wire from the masthead to the rail and set up by dead-eyes.

Shroud Whip. Usually called a rigging luff, consisting of a gun-tackle purchase for setting up shrouds.

Sick Bay. The ship's hospital.

Side Bench. The fore-and-aft planking fitted outboard over the air tanks of a boat so fitted, and to protect the tank.

Side Boys. The men manning the side in honor of visiting officers or officials.

Side Curtain. Canvas secured fore-and-aft in canopy cover openings as a protection against spray; also canvas spread between the rail and the ridge-ropes as a protection against the wind.

Side Lights. The red and green running lights carried on the port and starboard bows respectively of vessels underway.

Sight the Anchor. To heave an anchor up to the water's edge to make sure it is clear; it is then again let go.

Silt. Mud or sediment.

Single-Bank. One man or one oar to a thwart.

Single Block. A block with a single sheave.

Single Carrick Bend. See text.

Single Spanish Burton. A tackle with three single blocks. Seldom used.

Single Sticker. A sloop.

Single Up. To come up double lines so that only single parts remain secured.

Single Whip. See text.

Sing Out. To call out.

Siren. The shrieking device operated by steam and used as a warning signal.

Sisal Rope. Rope made from the fibre of the henequin plant.

Sister Block. A shell with two sheaves, one above the other; the falls lead in opposite directions.

Sister Hooks. Two iron flat-sided hooks reversed to one an-

other suspended from a thimble with the flat sides together when in place.

Sister Ships. Ships built on the same design.

Skeg. The continuation of the keel aft, protecting the propellers and taking the heel of the rudder.

Skids. Beams sometimes fitted over the decks for the stowage of heavy boats.

Skiff. A small light pulling boat.

Skin. The outside fold of canvas of a sail when furled. The inside or outside of a ship's plating.

Skipper. The captain.

Skylight. A covering either permanent or removable, fitting over a hatch and with hinged sashes; it admits air and light below decks.

Sky Pilot. The chaplain.

Slack. The part of a rope hanging loose. To ease off. The state of the tide when there is no horizontal motion. To be slow in tacking.

Slack Cloths. Baggy sail.

Slack Water. The condition of the tide when there is no horizontal motion.

Slant of Wind. A favorable change of direction of wind.

Sleeper. A partially submerged log.

Slew. A river inlet.

Sliding Gunter. A rig used in men-of-war boats and consisting of a jib and triangular foresail and mainsail, the luffs of the latter secured to topmasts sliding on the lower masts.

Slings. A fitting for hoisting a boat by a boat crane or boom and consisting of a metal ring with four pendants. Two of these pendants are for steadying lines athwartships and the other pendants shackle to chain bridles permanently bolted to the keel.

Slip. To let go by unshackling, as a cable; the lost motion of the propeller.

Slip-hook. A hook fitted with a tripping link so that it may be readily released, as in securing the gripes of a life-boat.

Slip Rope. A rope bent to the anchor cable outboard of the hawse-pipe and secured on the vessel's quarter; used in slipping the cable.

Slip Stopper. A chain stopper hooked or shackled to the deck and fitted with a slip-hook for holding the cable.

Sloop. A single-masted sailing boat with mainsail, and with headsails carried on a bowsprit and jib-boom.

Slope Oar. One who loafs at his oar.

Slush. The grease from salt pork or boiled beef, used for making a mast slippery.

Smack. A small fishing vessel, sloop or cutter rigged.

Small Stuff. Small cordage designated by number of threads or special names, such as ratline stuff, marline, etc., usually of American hemp, tarred.

Smart. Snappy, seamanlike; a smart ship is an efficient one.

Smiting Line. A line used in breaking a light sail sent up in stops.

Smothering Lines. Lines led to a compartment for smothering a fire by steam or by a chemical.

Snake. Wrapping a smaller rope around a larger one, similar to worming.

Snatch Block. A single block fitted so that the shell or hook hinges so that the bight of a rope may be passed through.

Snorter (also Snotter). A single line fitted with an eye secured to the foot of a mast to take the heel of a sprit, or to the yard of a lug rig into which the halliards hook.

Snub. To check suddenly.

Snug Down. To reduce sail preparatory to a blow.

Sny. A small toggle on a flag.

Sojer. One who dodges work.

Sonic Depth Finder. A device for indicating automatically the depth of the water.

Sound. To measure the depth of the water with a lead. Said of a whale when it dives for the bottom.

Sounding Balloon. A small balloon sent up without passengers but with recording meteorological instruments.

Sounding Machine. A machine consisting of a drum mounted on a stand and carrying the sounding wire; it may be unclamped so as to revolve freely when paying out the wire or may be wound in by crank handles.

Sounding Tube. A tube secured above the lead and registering the depth of water.

Southwester. An oil-skin hat with broad rear brim.

Span. A rope made fast at both ends with a purchase hooked to its bight; a wire rope between davit heads and set up by a turn-buckle.

Spanish Burton. A purchase consisting of a single block on the hauling part of another single block. Mechanical advantage, 4 to 1.

Spanish Windlass. A wooden revolving roller turned by a marlinespike thrust into turns of rope wound around it.

Spanker. The after mast and sail of a schooner having more than three masts.

Spanking. Large and satisfactory—as a spanking breeze.

Spanner. A tool for coupling hoses.

Spar Buoy. A long spar projecting vertically above water and with its lower end anchored.

Speak. To communicate with a vessel in sight.

Spectacle Eye. A metal piece fitted over a davit head and with two eyes, one for the guy and the other for the span.

Speed Cones. Conical shapes used in formation to indicate engine speeds.

Speed Light. The light at the after truck of men-of-war showing white or red and indicating changes in speed.

Spile. A pile.

Spill. To empty the wind out of a sail.

Spinnaker. A light racing triangular sail set on a spinnaker boom on the opposite side to the main boom when sailing free.

Spit Kit. A small wooden tub used as a spittoon.

Splice. To join two ropes together by tucking strands.

Splice the Main Brace. To have a drink.

Splinter Deck. The deck fitted with the lightest protective plating.

Spoke. A handle of a steering wheel.

Sponsor. One who christens a ship at launching.

Spoon Drift. The spray and water driven from the top of the waves in a storm.

Spreader. A horizontal iron or wooden spar fitted to a mast and used to spread the shrouds and stays.

Spring. A mooring or docking line leading at an angle of about 45 degrees with the fore-and-aft lines of the vessel. To turn a vessel with a line.

Spring Stay. A horizontal stay between lower mastheads.

Spring Tide. A tide of maximum range coming at the new and full moons.

Sprit. A small spar used to hoist the peak of a boomless and gaffless sail. The upper end of the sprit fits into a grommet or becket, and the lower end rests in a snorter secured near the foot of the mast.

Sprung. Warped.

Spuds. Vertical timbers holding a dredge in place.

Spun Yarn. Rough stuff made from long tow, laid up loosely left-handed of two, three or four

strands; used for seizings and small stuff.

Spur Shore. A wooden spar used to hold a vessel clear of a dock, fitted at the dock end with a truck and heel chains, and at the ship end with ring bolts for securing.

Spur Shore Heel Chain. The chain secured to cleats or bollards on a dock and to a half chock at the heel of a spur shore.

Spur Shore Shoe. A wooden block used as a rest for a spur shore against a vessel's side.

Spur Shore Truck. A truck on the dock supporting the heel of a spur shore.

Spy Glass. A small hand telescope.

Squall. A sudden and violent gust of wind.

Square Reef Knot. See text.

Square Mark. A reference mark of twine placed on running rigging to indicate when the gear is properly squared or suspended.

Squatting. The settling of the stern of a vessel at high speed.

Squilgee. A deck dryer composed of a flat piece of wood shod with rubber, and a handle.

Stagger. Said of a vessel when under so much press of canvas that she does not ride well.

Stanchions. Wooden or metal uprights used as supports.

Stand. The condition of the tide when there is no vertical motion.

Standard Compass. The compass used by the Navigator as a standard.

Standard Half Rudder. That rudder angle which at 12 knots will give a tactical diameter of 1,000 yards.

Stand By. A preparatory order.

Stand by the Oars. An order given to prepare to get the oars up or out.

Stand by to Wear (gybe). An order to prepare for wearing (gybing).

Standing Lug. A small boat sailing rig in which the sail is set on a yard and the tack is made fast to the mast.

Standing Part. That part of a line or fall which is secured.

Standing Rigging. That part of a ship's rigging which is permanently secured and not movable, e.g.: stays, shrouds, etc.

Starboard Tack. The tack on which the wind comes over a vessel's starboard side.

Start. To slack handsomely.

Station Bill. The posted bill showing stations of the crew at maneuvers and emergency drills.

Staunch. Stiff, seaworthy, able.

Stay. A rope of hemp, wire or iron used for supporting a mast.

Staysail. A sail set upon a stay.

Stay Tackle. A tackle made fast to a stay as in hoisting cargo out of a hatch.

Steady. An order to hold a vessel on the course she is maintaining.

Steadying Line. A line used for steadying purposes.

Steam Trawler. A trawler fitted with steam propulsion.

Steerage. The junior officers' quarters.

Steerage Way. The slowest speed at which a vessel will steer.

Steering Compass. The compass by which the ship is steered.

Steering Crutch. A metal swivel fitting on the quarter rail of a life-boat as a support for the steering oar.

Steering Gear. The gearing from steering wheel to tiller by which the tiller is moved.

Steering Light. The small white light sometimes carried abaft the funnel or aftermast by a towing vessel, for the vessel towed to steer by.

Steering Oar. A long heavy oar used for steering a life-boat and fitting into the steering crutch.

Steering Wheel. The wheel oper-

ating the steering gear and by which the vessel is steered.

Steeve. The angle of the bowsprit with the horizontal.

Stem. The timber at the extreme forward part of a boat secured to the forward end of the keel and supporting the bow planks.

Stem Winders. Steamers with engines well aft.

Step. The frame on the keelson into which the heel of a mast fits or steps.

Stern. The after part of the vessel.

Stern All. An order given to propel a boat astern by the use of the oars.

Stern Anchor. An anchor carried at the stern.

Stern Board. Progress backwards.

Stern Chase. A chase from directly astern.

Stern Chock. A chock fitted in the stern of a vessel; the stern towing chock consists of two large round chocks directly over the stern.

Stern Fast, Stern Line. A rope led over the stern of a vessel and used in securing her by the stern.

Stern Ladder. The ladder hung over a vessel's stern for the use of boat's crews.

Stern Light. The white running light shown at the stern of an overtaken vessel.

Stern Line. A mooring line leading from the stern of a vessel.

Sternpost. The aftermost vertical timber or casting and fitting into the after end of the keel.

Stern Sheets. The space in a boat abaft the after thwart.

Stevedore. A professional cargo stower.

Sticks. Masts.

Stiff. Said of a vessel when she stands up well without heeling under her canvas.

Stock. The crosspiece of an old-fashioned anchor, at right angles to the arms.

Stopper. A short length of rope secured at one end, and used in securing or checking a running rope, e.g.: deck stopper, boat-fall stopper, etc.

Stopper Knot. A double crown and a double wall, the crown being made first, the ends coming out of the side of the knot; used on the end of a deck stopper.

Stops. Rope or canvas pieces used in furling a sail.

Storeroom. The space provided for stowage of provisions or other material.

Storm. Force of wind 56 to 65 knots.

Storm Canvas. Small heavy sails used in heavy weather to replace the regular sails.

Storm Track. The path of a storm.

Storm Warning. A warning of the approach of a storm.

Storm Wave. The advancing edge of a storm.

Stove. Broken in.

Stow. To put in place.

Stowaway. A person illegally aboard and in hiding.

Stowing Anchor. An anchor stowed on deck other than on the bill-board.

Strake. A continuous planking or plating fitted end to end from stem to stern of a vessel's side.

Strand (ed). (1) a number of yarns twisted together, and which in turn may be twisted into rope. (2) A rope is stranded when a strand is broken. (3) Rope may be designated by the number of strands composing it; rope is commonly three-stranded. (4) A vessel run ashore is said to be stranded.

Strap. A ring of rope made by splicing the ends, used for slinging weights, holding the parts of a block together, etc. A rope, wire or iron binding encircling a block

and with a thimble seized into it for taking a hook.

Strato-cumulus. Dark clouds of large globular masses or rolls, with a horizontal base.

Stratus. The lowest clouds, forming a horizontal sheet of lifted fog.

Stream. To drop over an anchor buoy previous to letting go the anchor.

Stream Anchor. An anchor of medium weight formerly carried at the stern but now commonly stowed in various locations aboard ship, other than in the eyes or at the stern.

Stretchers. Foot braces for oarsmen and consisting of pieces of wood placed athwartships in the bottom of a pulling boat.

Stringer. A horizontal plank or plate secured to a vessel's frames and supporting beam-ends.

Stroke. The sweep of an oar; an order given at the catch of the stroke.

Strongback. A light spar lashed to a pair of boat davits and serving as a spreader for the davits.

Strong Breeze. Force of wind 22 to 27 knots.

Strong Gale. Force of wind 41 to 47 knots.

Strut. The bracket support for a vessel's tail shaft.

Studs. Pieces of metal fitted across the link of a chain to prevent kinking.

Studding Sail Halliard Bend. See text.

Studding Sail Tack Bend. See text.

Submarine Bell. A submerged sound transmitting apparatus actuated by timed mechanism as a warning of a danger to navigation.

Submarine Signal. A system for transmitting and receiving sound signals through the water, so that the direction of the transmitting source may be determined.

Sundowner. A martinet.

Sun Over the Foreyard. An expression used at first drink time.

Supercargo. A merchant vessel's officer charged with managing the ship's business.

Superstructure Deck. A partial deck above the main, upper, forecastle or poop deck, and not extending out to the side of the ship.

Surge. To slack suddenly. The heave of the sea.

Swab. A rope mop.

Swallow. The larger opening in a block above or below the sheave through which the fall leads.

Swamp. To sink by filling with water.

Sway Aloft. An order to hoist a yard or spar aloft.

Swell. Heave of the sea.

Swifter In. To bring two shrouds or stays close together by turns of rope.

Swig Off. To gather in on a rope by heaving out and down with the weight of the body, at the same time taking in the slack where secured.

Swing Ship. The evolution of swinging a ship's head through several compass points, to obtain compass errors for making a deviation table.

Swivel. A metal link with an eye at one end fitted so as to swivel and thereby keep turns out of the chain. A swivel is fitted near the inboard end of the first (5 fathoms) shot.

Tachometer. A mechanical apparatus for indicating shaft revolutions. One type also averages the revolutions of two or more shafts.

Tack. The lower forward corner of a fore-and-aft sail. Close hauled on the wind. To change from one tack to another by putting the helm down.

Tackline. The rope that hauls down the tack of a gaff topsail. A short length of line used to separate flags in a hoist.

Taffrail Log. The log mounted

on the taffrail and consisting of a rotator, a log line and a recording device.

Tail. The direction to which the stern swings.

Tail Block. A block with a tail of rope instead of a hook.

Tail On. An order to lay hold of a rope and pull away.

Tail Shaft. The after section of the propeller shaft.

Take a Turn. To pass a turn around a belaying pin or cleat and hold on.

Take In. To lower and furl the sails.

Taps. The bugle call for out lights.

Tar. A sailor.

Tarpaulin. Heavy canvas used as a covering.

Tattoo. The bugle call preparatory to taps.

Taunt. Said of a vessel having lofty spars.

Taut. With no slack; strict as to discipline.

Taut Bowline. Sailing close-hauled.

Teeth. Directly towards the wind.

Telemotor. A hydraulic device by which the movement of the steering wheel operates the rudder and indicates the position of the rudder.

Tend. To man. The direction of the cable when anchored.

Tender. Crank or heeling unduly; a vessel accompanying a group of vessels for effecting repairs, carrying stores, etc.

Teredo. A worm which eats into the unprotected hulls of wooden ships.

"That's high." An order to cease hoisting.

Thimble. An iron ring grooved on the outside for a rope grommet.

Third Deck. A complete deck next below the second deck.

Thole-pin. A metal pin fitting into a socket on the rail and over which a rope grommet is placed to serve as a rowlock.

Thorough Foot. A fall of a tackle which is twisted or a block of which has been capsized through the falls.

Thread. Yarns making up strands; small rope is sometimes designated by the number of threads going to make up a strand; e.g.: six thread, fifteen thread, etc.

Three-fold Purchase. See text.

Three Sheets in the Wind. Well under the influence of liquor.

Throat. The forward upper corner of a fore-and-aft sail. The junction of the shank and arm of an anchor.

Throat Seizing. A seizing for stopping the end of a rope to its own part, by double round turns, the first turn through an eye in one end, and finished off by round turns across the middle of all turns.

Thrum Mat. A mat used to prevent chafing; specifically the mat placed between a vessel's side and a spur shore shoe.

Thrums. Short strands of rope with strands unlaid and stuck through a mat to make a rough surface.

Thumb Cleats. Jamming cleats used on yachts for sheets and running backstays.

Thwart. The athwartships seats in a boat.

Thwartships. At right angles to the fore-and-aft line.

Thwart Stanchions. The vertical stanchions fitted amidships in a boat under each thwart, as a support for the thwart.

Tide-rip. Waves and eddies caused by the tide in shoal water.

Tide Rode. Riding to the tide and not to the wind.

Tide-way. The part of a channel in which the tide ebbs and flows.

Tier. To stow the cable in the chain locker.

Tiller. A short piece of iron or wood fitting into the rudder head and by which the rudder is turned.

Tiller Ropes. The ropes connecting the tiller to a drum revolved by the steering ropes.

Timber Hitch. See text.

Timber Hitch and Half Hitch. See text.

Toggle. A wooden or metal pin slipped into a becket and used for separating and securing gear.

To Leeward. Away from the wind.

Tompion (pronounced **Tompkin**). The wooden plug placed in the muzzle of a gun to keep out dampness.

Tongue. The block of wood secured between the jaws of a gaff and which travels on the mast. It is fitted with a bolt between the jaws so as to ride smoothly on the mast.

Tonnage. Cargo capacity.

Top. The platform at the top of a mast; to top a boom is to lift up its end.

Top Hamper. The spars and rigging above the decks.

Top Heavy. Too heavy aloft.

Topmast. The mast next above the lower mast.

Topping Lift. A rope used for topping up a boom and taking its weight.

Topping Lift Bridle. Where fitted, the bridle secured to the outer end of the boom and through which the topping lift is rove.

Topsail. A sail set over a lower sail.

Topsail Halliard Bend. See text.

Topsail Schooner. A schooner with the sails above the foresail square-rigged.

Top Sides. Above decks.

Torch. A light used in signalling.

Toss Oars. An order given to raise the oars from the rowlocks to a perpendicular position, blades fore-and-aft, with the handles resting on the bottom of the boat.

Touch. Luffing until the leech shivers.

Tow. To pull through the water. Vessels towed.

To Windward. Towards the wind.

Towing Light. The white light or lights carried by a towing vessel which signifies she is towing.

Towing Spar, Position Buoy. The spar towed by men-of-war in a fog as an aid to the next astern in column.

Track. The path of a vessel.

Trades. The practically steady winds found in the tropics and blowing towards the Equator—NE in the Northern and SE in the Southern hemisphere.

Trail. An order given in a small boat fitted with trailing lines to allow the oars to trail over the side.

Transom. The athwartships timbers bolted to the sternpost. Stationary couches.

Traveller. An iron ring for the sheet blocks of staysails and fore-and-aft sails, sliding athwartships along a deck horse.

Trawler. A fishing vessel fitted with a trawl which she drags over the bottom.

Treble-fold Block. A block with three sheaves.

Trend. Same as throat.

Trice. To haul up.

Tricing Line. A line used for suspending articles.

Trick. The period of time during which the steersman remains at the wheel.

Trim. The angle to the horizontal in which a vessel rides; to handle the sheets so as to make the most out of the wind; ship shape.

Trimming Tanks. Tanks used for ballast.

Trip. To let go.

Tripping Line. A line used for capsizing a sea anchor.

Tropical Hurricane. A tropical cyclonic storm.

Trough. The hollow between two waves.

Truck. The flat circular piece of wood secured at the top of the highest mast or at the top of a flagstaff.

Trunk. A vertical shaft.

Tug Boat. A small vessel fitted for towing purposes.

Tumble Home. The amount the sides of a vessel come in from the perpendicular.

Turk's Head. An ornamental knot.

Turn Buckle. A metal appliance consisting of a thread and screw capable of being set up or slacked back and used for setting up standing rigging.

Turning Buoy. A buoy marking a turn in a channel.

Turn of the Bilge. The point where the frames of a vessel turn from the vertical to the rounding of the bilge.

Turn To. An order to commence ship's work.

Turn Turtle. To capsize.

Twice-laid. Rope laid up from old yarns.

Two Blocks. When the two blocks of a tackle have been drawn as close together as possible.

Two Bowlines. See text.

Two-fold Purchase. See text.

Two Half Hitches. A hitch formed by leading the end over and under and up through the standing part and repeating the process; a very useful hitch especially in making fast moderate sized lines, but it will jamb.

Two Topsail Schooner. A topsail schooner with a square-rigged main topsail.

Typhoon. A violent hurricane found in the China Sea and Indian Ocean at the change of the monsoons.

Umbrella. The conical shield at the top of the smokestack.

Unbalanced Rudder. A rudder whose area does not extend forward of the axis of rotation.

Unballast. To discharge a vessel's ballast.

Unbend. To cast adrift or untie.

Unbitt. To cast the turns of a cable off the bitts.

Under Below. A warning from aloft.

Undercurrent. The sub-surface current where there is no surface current, or where the surface current runs in the opposite direction.

Under-foot. When the anchor is directly under the hawse hole.

Under Hack. Confinement of an officer as a punishment.

Under-manned. Insufficient number of crew, short-handed.

Under-run. To haul a boat under a hawser; to raise up the bight of a hose to empty it of water.

Under the Lee. To leeward of the shore or of another vessel.

Undertow. A current off shore in surf.

Underway. Said of a vessel when not at anchor, nor made fast to the shore, nor aground.

Unfurl. To cast loose a sail by throwing off the gaskets.

Union. The inner upper corner of a flag.

Unmoor. To heave up one anchor, leaving the other down.

Unreeve. To haul a line out of a block.

Unrig. To take the rigging off a vessel.

Unship. To take apart or to remove from its place.

Unwatched. Said of a lighthouse not tended.

Up Anchor. The order to weigh the anchor and get underway.

Up and Down. Perpendicular.

Up Behind. An order to cease pulling and slack up roundly so that the gear may be belayed.

Up Oars. An order given to

raise the oars from the boat to a position of toss.

Upper Deck. A partial deck amidships, over the main deck.

Upper Works. The parts of a vessel proper above the main deck.

Up Take. The enclosed trunk connecting a boiler or a group of boilers to the smoke stack.

Vane. A piece of bunting flown at the truck to indicate the direction of the wind.

Vangs. Steadying lines from the peak of a gaff to the rail.

'Vast. An order to cease.

Veer. To slack off and allow to run out; said of a change of direction of wind.

Veer and Haul. To slack up and haul away alternately.

Veil. A thin cloud covering.

Velocity of Translation. The speed of being carried along—usually referring to a storm center.

Ventilator. A wooden or metal pipe used to supply or to exhaust air.

Ventilator Cowl. The swivelled opening at the top of a ventilator.

Ventilating System. The system consisting of ventilating fans and piping, to circulate fresh air in the vessel.

Vertical Keel Plate. A vertical plate running from stem to stern post and secured at its lower edge to the flat keel plate.

Very's Signals. Red, white and green stars fired in a pistol and used in a special code for signalling purposes.

Viol Block. A block similar to a snatch block but without a hinge; the bight of a rope may be dropped into the sheave.

Visible. Capable of being seen on a dark night with a clear atmosphere.

Waist. The portion of the deck between the forecastle and quarter-deck.

Waist Breast. A breast line from amidships, keeping a vessel in to the dock; sometimes used in mooring or docking.

Wake. A vessel's track; behind.

Wales. Strong planks running fore-and-aft on a vessel's sides.

Wale Shore. A spar used to keep a ship upright in dock, one end resting against the ship's side and the other against the side of the dock, wedges being inserted to set it tight.

Walk Back. An order to keep the gear in hand but walk back with it towards the belaying point.

Wall and Crown. See text.

Wall Knot. See text.

Wall Sided. Perpendicular-sided.

Wardroom. Commissioned officers' quarters on a man-of-war.

Warp. To haul ahead by a line or anchor.

Warping Chock. A chock used for warping or hauling along a vessel at a dock.

Washboard. The thin planking projecting above the rail of a small boat to increase the freeboard and to keep out spray and water.

Waste. Cotton yarn used for cleaning purposes.

Watch Cap. A canvas cover secured over a funnel when not in use.

Watch ho! Watch! The word passed along from forward aft in heaving the deep-sea lead as a warning that the line is running out.

Watch-and-Watch. Two watches alternating on deck.

Watch Officer. An officer taking his turn as officer-of-the-watch.

Watch Tackle. Same as luff tackle.

Water Boat. A boat fitted with water-tanks and a pump for transporting and supplying vessels with fresh water.

Water-borne. Clear of the bottom.

Water Breaker. A small cask carried in ship's boats for drinking water.

Waterline. The line painted on the side of a vessel at the water's-edge to indicate the proper trim.

Water-logged. Filled with water but afloat.

Water Monkey. A clay jar for keeping drinking water cool.

Water's Edge. The surface of the water.

Water-tight. Capable of keeping out water.

Waterway. The gutter at the sides of a ship's deck to carry off water through the scuppers.

Way Enough. An order given to finish the stroke, toss and boat the oars.

Wear. To change from one tack to another by putting the helm up.

Weather. To windward.

Weather Bound. Detained in port by weather conditions.

Weather-Breeder. A clear day but with evident signs of approaching bad weather.

Weather-Cloth. Canvas, spread for the protection from the wind.

Weather-eye. To keep a weather-eye is to be on the alert.

Weather Gauge. The situation of a vessel to windward of another vessel.

Weather Helm. The tiller put over to windward; a vessel carries a weather helm when it is necessary to put the tiller to windward to hold the course.

Weather Side. The windward side.

Weather Tide. A tide setting to windward.

Weeping. A slight leak.

Weigh. To lift the anchor off the bottom.

Well! An order meaning sufficient.

Well Deck. That part of the main deck of a vessel having a raised forecastle and poop.

Westerlies. The prevailing winds of the temperate zone, especially steady in the southern hemisphere.

Wet Bulb Thermometer. An instrument for measuring the temperature of the moist air; by comparison with the dry bulb thermometer the relative humidity of the atmosphere is measured.

Whale Back. A vessel constructed with a rounded deck similar to a whale's back and with large cargo capacity.

Whaleboat. A sharp-ended pulling life-boat issued to vessels of the U. S. Navy, single or double-banked, pulling 5 or 6 oars single-banked or 12 oars double-banked, fitted with sails of double standing lug rig without jib. They are 24 feet, 28 feet or 30 feet in size.

Wheel Ropes. The ropes connecting the steering wheel with the drum of the steering gear.

Whelps. Iron pieces bolted to the wooden barrel of a windlass to prevent the chain from cutting the barrel.

Where Away. A call in answer to the report of a lookout of an object sighted.

Wherry. A light, handy pulling boat issued to certain vessels of the U. S. Navy, principally for officers' use, in the following sizes: 12 feet, 14 feet.

Whip. Same as single whip.

Whip and Runner. See text.

Whipping. A method of preventing the ends of a rope from unlaying or fraying by turns of stout twine with the ends tucked.

Whiskers. Horizontal spars of wood or iron projecting on each side of the bowsprit and to give spread to the jib-boom guys.

Whistling Buoy. A buoy fitted with a whistle actuated by the sea.

White Cap. The white froth on the crests of waves.

White Squall. A sudden squall accompanied by white spoondrift.

Whole Gale. Force 48 to 55 knots.

Wide Berth. At a considerable distance.

Wig-Wag. A code indicated by sweeps of a flag to the right, left or front.

Wildcat. A sprocket wheel on the windlass for taking the links of the chain cable.

Winch. An engine secured on deck and fitted with drums or gypseys driven on a horizontal axle.

Wind (a Steamer). To turn a vessel end-for-end, usually by the use of lines.

Wind-bound. Said of a vessel when forced to lie at anchor due to strong or contrary winds.

Windjammer. A sailing ship, especially a square-rigged ship.

Windlass. An anchor engine used for heaving in the chain cable and anchor.

Windsail. A canvas trunk spread to admit air below decks.

Wind Scoop. A metal scoop fitted into an airport to direct air into the ship.

Windward. Toward the wind.

Wing and Wing. Sailing with booms on opposite sides.

Wire Rope Clips. "U" shaped metal clamps for holding two parts of wire together.

With the Sun. Right-handed.

Work (a Ship). To handle by means of sails or engines and gear.

Work to Windward. Making up against the wind.

Work Up. To make progress to windward.

Worming. Filling up the lays of a rope preparatory to parceling by spiral windings of small stuff so as to make a round surface.

Wreck Buoy. A buoy painted with red and black horizontal stripes and marking a wreck.

Wrecker. One who makes a business of salvaging wrecks.

Wriggle. An eyebrow.

Wring. To buckle, to twist out of shape.

Yacht. A boat especially designed or fitted for pleasure purposes.

Yard. A light spar to which the head of a lug rig sail is secured; in a square-rigged vessel, the spar suspended horizontally from the mast and to which the head of a square sail is bent.

Yard-arm Blinker. A signal light carried on the yard-arm of men-of-war and operated to indicate dots and dashes.

Yardarm to Yardarm. Said of square-rigged vessels alongside one another with yardarms touching.

Yard Slings. The middle of the yard of a square-rigged vessel; the chain suspension of a lower yard.

Yarns. (1) Twisted fibres used for rough seizings, and which may be twisted into strands. (2) Tales —to "spin a yarn" is to tell a story.

Yaw. To steer wildly or out of the line of the course, as when running with a heavy quartering sea.

Yawl. A rig similar to a sloop-rig but with a small after fore-and-aft sail set on a short jigger mast.

Yoke. The horizontal wooden piece fitting across the head of the rudder of a small boat.

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TABLE XXV

CONSTRUCTION	TYPE	REMARKS
19-Wire Strand	Standing Rigging	Maximum corrosion resistance and strength—minimum stretch, and flexibility—difficult to splice.
6 x 7, 7 x 7	Standing Rigging	Lower strength, less corrosion resistance, more stretch, greater flexibility than strand—easily spliced.
6 x 19, 7 x 19	Running Ropes	Slightly higher in strength than 6 x 7 and 7 x 7—Approximately same stretch, less corrosion resistance, *but* considerably more flexible—easily spliced
6 x 12 (Fibre center strands)	Running Ropes	Lower strength than 6 x 19, with greater stretch and flexibility and about the same corrosion resistance—easily spliced
6 x 6 x 7 (Tiller Rope)	Running Ropes	Lowest strength and corrosion resistance, maximum stretch and flexibility—easily spliced

(*Courtesy John A. Roebling Sons Co.*)

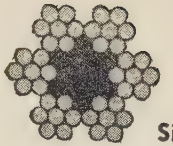


TABLE XXVI
6 x 7 Rigging Rope
Six Strands of Seven Wires each

Diam. in.	Breaking Strength in Pounds			Approx. Weight lbs. per 100 ft.	
	Galv. "Blue Center" Steel	Phos-phor Bronze	Stain-less Steel	Steel	Phos-phor Bronze
1/16	310	150	385	.585	.655
3/32	700	340	800	1.33	1.49
1/8	1,240	600	1,400	2.34	2.62
5/32	1,920	920	2,100	3.66	4.10
3/16	2,760	1,320	3,000	5.27	5.90
7/32	3,740	1,770	4,000	7.17	8.03
1/4	4,860	2,280	5,200	9.40	10.5
5/16	7,560	3,520	8,000	15.0	16.4
3/8	10,600	5,000	11,500	21.0	23.5
7/16	14,200	6,750	15,400	29.0	32.2
1/2	18,500	8,680	19,800	38.0	42.0
9/16	23,400	10,800	24,800	48.0	53.0
5/8	28,800	13,200	30,300	59.0	65.6
3/4	41,000	18,900	42,400	84.0	94.5
7/8	55,400	25,300	56,000	115.0	129.0
1	72,000	32,500	71,400	150.0	168.0

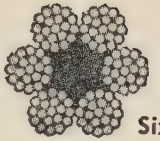


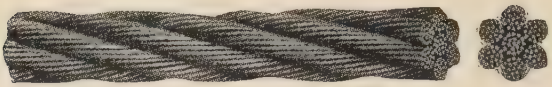
TABLE XXVII
6 x 19 Rigging Rope
Six Strands of Nineteen Wires each

Diam. in.	Breaking Strength in Pounds			Approx. Weight lbs. per 100 ft.	
	Galv. "Blue Center" Steel	Phos-phor Bronze	Stain-less Steel	Steel	Phos-phor Bronze
1/8	1,360	615	1,500	2.50	2.80
5/32	2,060	950	2,300	3.90	4.37
3/16	2,960	1,370	3,200	5.63	6.30
7/32	3,960	1,830	4,300	7.65	8.57
1/4	5,220	2,380	5,600	10.00	11.20
5/16	8,080	3,670	8,600	16.00	17.50
3/8	11,300	5,240	12,200	23.00	25.20
7/16	15,100	7,080	16,400	31.00	34.30
1/2	19,400	9,210	21,200	40.00	44.80
9/16	24,200	11,500	26,500	51.00	56.60
5/8	29,800	14,150	32,600	63.00	69.90
3/4	42,600	19,950	46,200	90.00	101.00
7/8	58,000	26,700	61,900	123.00	138.00
1	75,600	34,600	79,500	160.00	179.00

(Courtesy John A. Roebling Sons Co.)

TABLE XXVIII 7 x 19 Aircraft Cord

(Standard or Preformed)



Diameter inches	Breaking strength, pounds		Approximate weight, pounds per 100 feet
	Tinned or Galvanized	Stainless Steel	
3/8	14,400	13,000	26.45
5/16	9,800	9,600	17.71
9/32	8,000	8,000	14.56
1/4	7,000	6,600	12.00
7/32	5,600	5,200	9.50
3/16	4,200	3,900	6.47
5/32	2,800	2,800	4.44
1/8	2,000	1,900	2.88

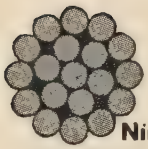


TABLE XXIX

Nineteen-Wire Strand

Diam. in.	Breaking Strength in Pounds		Approx. Weight, lbs. per 100 ft.
	Galv. "Blue Center" Steel	Stainless Steel	Steel
1/16	550	550	.81
3/32	1,200	1,200	1.82
1/8	2,100	2,100	3.24
5/32	3,300	3,300	5.05
3/16	4,700	4,700	7.28
7/32	6,300	6,300	9.90
1/4	8,200	8,200	13.00
9/32	10,300	10,300	16.40
5/16	12,500	12,500	20.20
3/8	17,600	17,600	29.10
7/16	23,400	23,400	39.60
1/2	29,700	29,700	51.80
9/16	36,500	36,500	65.50
5/8	44,000	44,000	81.00

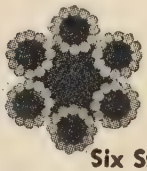


TABLE XXX

6 x 12 Running Rope

Six Strands of Twelve Wires each

Diam. in.	Breaking Strength in Pounds		Approx. Weight lbs. per 100 ft.	
	Galv. Plow Steel	Phosphor Bronze	Steel	Phosphor Bronze
1/8	700	380	1.64	1.84
3/16	1,520	845	3.69	4.13
1/4	2,760	1,470	6.56	7.35
5/16	4,260	2,270	10.00	11.05
3/8	6,020	3,230	15.00	16.80
7/16	8,020	4,380	20.00	22.40
1/2	10,200	5,650	26.00	29.40
9/16	12,860	7,100	33.00	37.30
5/8	15,800	8,740	41.00	46.00
3/4	22,600	12,250	59.00	66.40
13/16	26,600	14,300	69.00	77.90
7/8	30,800	16,600	80.00	90.40
1	40,000	21,300	105.00	118.00
1 1/16	45,200	.....	119.00	.....

(Courtesy John A. Roebling Sons Co.)

1.00 VAN
5.00 DUTCH
10.00 BOOKS
10.00 BLOTCH

27.65
50.00

77.65